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The Engineer

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PUBLIC NOTICES

Architect Required by the GOVERNMENT of SIERRA LEONE in the PUBLIC WORKS DEPARTMENT, for two tours of not less than 12 nor more than 18 months' continuous residential service. Salary £600 a year. Free quarters and passages and liberal leave on full salary. Candidates, aged 28-35, should have served articles with a member of the Royal Institute of British Architects and have passed the examination qualifying for associate membership of that Institute, or possess the Diploma of some recognised college which is accepted by that Institute as exempting candidates from taking the examination of the Institute. Must be first-class draughtsman, capable of designing and carrying out buildings, taking out quantities, preparing details and specifications, and must be competent to execute building surveys, set out buildings, and lay out roads.—Apply at once, by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting M/13,190. 8222

Assistant Locomotive SUPERINTENDENT REQUIRED for the NIGERIAN GOVERNMENT RAILWAY, for two tours of from 12 to 18 months' service, with prospect of permanency. Salary £480 a year for the first three years, then £510, rising by annual increments of £30 to £720, and thence by annual increments of £40 to £920. Outfit allowance of £60 on first appointment. Free quarters and first-class passages and liberal leave on full salary. Candidates, age 25 to 35, should be of good education and preferably possess an approved Engineering Diploma. They should have had a thorough training in the workshops of a British railway or well-known locomotive firm, should be conversant with the repair and erection of locomotives, carriages and wagons and be well up in drawing-office work and have had running experience. Preference will be given to applicants who have acted in a supervising capacity.—Apply at once by letter, stating age and particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting M/Nigeria, 13,159. 8227

Chief Engineer Required for FALKLAND ISLANDS GOVERNMENT SHIP "DISCOVERY," now fitting out for marine research chiefly in Antarctic waters.

Candidates must be British and hold First Class Board of Trade Certificate and must have had previous experience in Antarctic or Arctic vessels. Age 30 to 45, preferably under 40. Pay £492 15s. a year, with free victualling and also uniform outfit on first appointment.

Forms of application can be obtained by letter from the SECRETARY, "Discovery" Committee, Colonial Office, S.W.1, not later than the 7th February. Requests for form must be accompanied by statement of special experience mentioned above. Applications from candidates not possessing such experience will not be considered. 8221

Section Engineers (6) REQUIRED for the Construction Branch of the FEDERATED MALAY STATES RAILWAYS, for three years' service, with possible extension. Salary 400 dollars a month, rising to 475 dollars a month by annual increments of 25 dollars a month plus a temporary non-pensionable allowance of 10 per cent., which is liable to cancellation or revision, plus a commuted field allowance of 50 dollars a month. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is at present considerably less than that of 2s. 4d. in the United Kingdom. Free passage provided. On expiration of agreement a bonus of four and a half months' salary may be allowed provided the work and conduct of the person engaged has been in every way satisfactory. Candidates, age 25 to 38 and unmarried, must be fully qualified railway engineers who have received good training and experience on recognised European, American or Colonial railways. Members or associate members of the Institution of Civil Engineers preferred.—Apply at once by letter, stating age and particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting at top of application M/13,284. 8253

INDIAN SERVICE OF ENGINEERS. STATE RAILWAYS.

The Secretary of State for India in Council will in 1925 APPOINT TWO ASSISTANT EXECUTIVE ENGINEERS for this service, if so many suitable candidates present themselves.

Every candidate must be a British subject, or a ruler or subject of any State in India in respect of whom the Governor-General of India in Council has made a declaration that he is to be considered eligible.

Candidates must be not less than 21 years, and not more than 24 years of age on 1st August, 1925.

They must either (1) have obtained one of certain recognised University Degrees or other distinctions in Engineering, or (2) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers or been exempted by the Institution from such Examination, or (3) produce the required evidence that they are otherwise eligible under the Regulations. They must in addition have had at least one full year's practical experience of Civil Engineering under a qualified Civil Engineer at the time when they appear before the Selection Committee.

Applications from candidates must reach the India Office not later than 1st April. Printed forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, Whitehall, London, S.W.1. 8184

Borough of Torquay Electricity Department.

STRUCTURAL STEELWORK FOR PROPOSED EXTENSIONS TO NEWTON ABBOT POWER STATION: SPECIFICATION P. 18.

The Torquay Corporation HEREBY INVITE TENDERS for the SUPPLY, DELIVERY and COMPLETE ERECTION of the STRUCTURAL STEELWORK REQUIRED for the proposed Extensions of their Newton Abbot Power Station.

Copies of the specification may be obtained from the undersigned on payment of a deposit of £2 2s., which will be returned to bona fide Tenderers.

Extra copies may be obtained on the additional payment of 10s. 6d. per copy, which is not returnable.

Sealed Tenders, endorsed "Structural Steelwork," must be addressed to the undersigned not later than Friday, the 13th February, 1925.

The Corporation does not bind itself to accept the lowest or any Tender.

H. P. G. WOODS, M.I.E.E., A.M.I.E.E.,
Borough Electrical Engineer and Manager.
Electricity Offices,
Upton Valley, Torquay. 8205

Borough of Bridlington.
EXTENSIONS TO ELECTRICITY WORKS.

The Bridlington Borough Council invite TENDERS for the SUPPLY and ERECTION in their Electricity Works at Brett-street, Bridlington, of the following:

SPECIFICATION No. 1.—ONE 600 K.W. STEAM TURBINE, REDUCTION GEAR, and DIRECT-CURRENT GENERATOR.

A copy of the specification can be seen at, and obtained from, the offices of Messrs. Kennedy and Donkin, 8, Broadway, Westminster, S.W.1, on and after Monday, the 2nd February, upon payment of a deposit of £2 2s. (cheque, postal order or money order) An additional copy of the specification can be obtained upon payment of a deposit of £1 1s. These deposits will be returned after the receipt of a bona fide Tender, and on the return of the specification.

Tenders, on the prescribed form, enclosed in sealed envelopes, and endorsed on the outside "Extensions to Electricity Works: Tender to Specification No. 1," must be delivered at the office of the undersigned not later than Monday, the 16th February, 1925.

The Council do not bind themselves to accept the lowest or any Tender.

GEORGE MELVIN,
Town Clerk.
Town Hall, Bridlington,
24th January, 1925. 8191

The Bengal and North-Western RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive TENDERS for the SUPPLY of:—

1000 TYRES for CARRIAGES and WAGONS, as per specifications to be seen at the Company's offices.

Tenders, addressed to the undersigned and marked "Tender for C. and W. Tyres," with name of firm tendering, to be lodged not later than Noon on Tuesday, the 17th day of February, 1925.

For each specification a fee of 10s. will be charged, which cannot under any circumstances be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE,
Managing Director.
237, Gresham House, Old Broad-street,
London, E.C. 2, 27/1/1925. 8209

The South Indian Railway Company, Limited, are prepared to receive TENDERS for the SUPPLY of:—

1. INDIA RUBBER VIBRATING PADS.
2. GALVANISED FENCING PALES.
3. MISCELLANEOUS ARTICLES.
4. DOG SPIKES.
5. PRESSED STEEL SLEEPERS.
6. STRUCTURAL STEEL WORK (SAW MILL).
7. GOODS WAGONS (B.G.).

Specifications and forms of Tender will be available at the Company's Offices, 21, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for India Rubber Vibrating Pads," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 13th February, 1925, for Specifications Nos. 1, 2, 3, 4, and 5, and on Friday, the 27th March, 1925, for Specifications Nos. 6 and 7.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5s. for each copy of Specifications Nos. 1, 2, and 3; of 10s. for each copy of Specification No. 4; and of £1 for each copy of Specifications Nos. 5, 6, and 7.

Copies of the drawings may be obtained at the offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.
91, Petty France, S.W.1,
27th January, 1925. 8235

Manchester Ship Canal Company.

The Directors of the Manchester Ship Canal Company are prepared to receive TENDERS from experienced contractors for the CONSTRUCTIONAL STEELWORK, to be erected on the site for the Company's New Offices, situate on the west side of King-street, Manchester.

Copies of the drawings and schedule with specification and form of Tender can be obtained at the office of the Architect for the new Offices, Harry S. Fairhurst, A.R.I.B.A., 14, Chancery-lane, Spring-gardens, Manchester, on payment of Two Guineas, which is not returnable.

Sealed Tenders, addressed to the undersigned and endorsed "Tender for Structural Steelwork," should be delivered at this office on or before 10 a.m. on the 10th day of February, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

F. A. EYRE,
Secretary.
41, Spring-gardens, Manchester,
January, 1925. 8179

Metropolitan Water Board.
TENDERS FOR THE SUPPLY OF STORES, &c.

The Metropolitan Water Board invite TENDERS for the SUPPLY of the undermentioned STORES, &c., for the periods of six or twelve months, commencing 1st April, 1925, as the Board may decide:—

Tender No.

1. Bricks, Fire-bricks, Cement, &c.
2. Brushes, Brooms and Handles.
3. Cast Iron Pipes and Irregular Castings.
5. Cotton Waste, Engine Wipers and Mutton Cloths.
6. Hemp, Yarn, Rope, House Flannel, Mats, &c.
7. Hire of Horses, Carts and Petrol Lorries and Supply of Sand and Ballast.
8. Iron and Steel.
9. Bolts and Nuts, Screws, Files, Tubes, Shovels and Picks.
10. Lead, Brass, Copper, Zinc and Glass.
11. Repair of Meters (Siemens).
12. Fuel Oil, Oils (Lubricating), Kerosene, Motor Spirit, Greases, Tallow, &c.
13. Oulman's Sundries, Soap, Tar, Gas Mantles, Metal Polish.
14. Packings, Rubber Goods, &c.
15. Paints, Varnishes, Linseed Oil, Turpentine, &c.
17. Pipe Laying Repairs, Alterations, &c.
18. Scrap Iron, Purchase and Removal of.
19. Small Iron, Brass, Gun-metal and other Castings.
20. G.M. Stopcocks and Ferrules.
21. Sluice Valves and Spindles, Hydrants, G.M. Outlets and Cans.
22. Timber, Hard and Soft Woods
23. Maintenance of Weighing Machines.
24. Electric Lamps.
26. Furnace Refuse, Disposal of.

Tenders must be made on the official forms, which may be obtained from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery-avenue, E.C. 1, on and after Thursday, 22nd January, 1925, by personal application (Room 156) or upon forwarding a stamped addressed brief envelope.

Applicants should refer to the number of the Tenders for which forms are required.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk, Metropolitan Water Board, New River Head, 173, Rosebery-avenue, Clerkenwell, E.C. 1," and endorsed "Tender for ———," must be delivered at the offices of the Board (Room 122) not later than 11 a.m. on Wednesday, 11th February, 1925.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.
Offices of the Board:
New River Head,
173, Rosebery-avenue, Clerkenwell, E.C. 1,
16th January, 1925. 8132

City and Royal Burgh of Dundee
ELECTRICITY DEPARTMENT.

The Corporation invites TENDERS for the SUPPLY, DELIVERY and LAYING COMPLETE of the EXTENSIONS to the CIRCULATING WATER SUPPLY and DISCHARGE PIPES, consisting of 30in., 42in. and 48in. diameter Cast Iron Flanged, and Spigot and Faucet Pipes.

Copies of the specification, form of Tender and general conditions of contract, along with drawings, may be obtained from the undersigned at the head office, Dudhope Crescent-road, Dundee, upon the deposit of Two Guineas, which sum will be returned upon the receipt of a bona fide Tender.

Tenders (sealed in envelopes provided) to be lodged with the Town Clerk, City Chambers, Dundee, not later than by Twelve Noon on Monday, 16th February, 1925.

The Corporation does not bind itself to accept the lowest or any Tender.

D. H. BISHOP, B.Sc., M.I.E.E.,
General Manager and Engineer.
Electricity Supply Department,
Dudhope Crescent-road,
Dundee,
Monday, 26th January, 1925. 8196

Southampton Corporation
WATERWORKS.
TENDERS FOR PIPES.

The Corporation invite TENDERS for the SUPPLY of 600 Tons of 4in. diameter CAST IRON SPIGOT and SOCKET PIPES.

The pipes must comply with the British Standard Specification for Class "B."

Any further particulars may be obtained upon application to the Waterworks Engineer at his offices, 21, Shirley-road, Southampton.

Sealed Tenders, stating time required for commencement and completion of delivery, suitably endorsed, must be delivered at the Town Clerk's Office, Southampton, by 10 a.m. on the 12th February next.

No pledge is given to accept any Tender.

R. R. LINTHORNE,
Town Clerk.
23rd January, 1925. 8189

Tees Valley Water Board.
SUNTHORPE SUPPLY, 1925.
CONTRACT NO. 3.
PUMPING MACHINERY.
TO CONTRACTORS.

The Tees Valley Water Board are prepared to receive TENDERS from competent persons willing to enter into a contract for the SUPPLY of PUMPING MACHINERY and ERECTION thereof at their Pumping Station in Normanby-road, South Bank, near Middlesbrough.

The drawings may be seen and copies of the specifications and bills of particulars obtained at the office of the undersigned, Municipal Buildings, Middlesbrough, and of the Engineers, Messrs. James Mansergh and Sons, 5, Victoria-street, Westminster, London, S.W.1, on and after Tuesday, the 20th instant, on deposit of £2, which will be returned after the receipt of a bona fide Tender, with the bills of particulars fully priced out. Early application for particulars is desirable, as only a limited number will be given out.

Sealed Tenders, endorsed "Pumping Machinery," are to be delivered at my office at or before Noon on Thursday, the 5th day of February, 1925.

The Board do not bind themselves to accept the lowest or any Tender.

(Signed) THOS. S. CLAVERT,
Clerk to the Board.
Water Board Offices, Middlesbrough,
16th January, 1925. 8104

Bombay, Baroda, and Central India Railway.
3 TEMPORARY ASSISTANT ENGINEERS.

The Directors are prepared to receive APPLICATIONS (by letter only) for APPOINTMENT to the above POSTS on the Company's Railway in India.

Candidates should be between 24 and 28 years of age, and must have had a good general and technical education and have obtained a degree at a recognised Engineering College or have passed the Associate Membership Examination of the Institution of Civil Engineers. In addition they must possess at least one year's practical experience with a railway company or on public works.

SALARY.—Rs. 450 and upwards per calendar month, according to age.

TERMS.—A three years' agreement in the first instance, first-class free passage to India and home again on satisfactory termination of services.

The selected candidates will be required to pass a strict medical examination by the Company's Consulting Physician before appointment.

Applications, giving full details of candidate's career, in chronological order (with dates), together with COPIES ONLY of testimonials, &c., must be addressed to the undersigned not later than the 20th February, 1925.

S. G. S. YOUNG,
Secretary.
Offices: The White Mansion,
91, Petty France, Westminster, S.W.1,
28th January, 1925. 8234

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PUBLIC NOTICES

The Madras and Southern MAHRATTA RAILWAY COMPANY, LTD.

The Directors are prepared to receive TENDERS for: 187 TONS (Approx.) SPRING STEEL, in accordance with the specification, which may be seen at the offices of the Company. The charge for the specification is One Guinea (£1 1s.), which will not be returned.

Tenders must be sent in, addressed to the SECRETARY, not later than 2 p.m. on Tuesday, the 17th February, 1925, and marked "Tender for Spring Steel."

The Directors do not bind themselves to accept the lowest or any Tender.

Company's Offices:
25, Buckingham Palace-road,
Westminster, S.W. 1.
27th January, 1925. 8225

Egyptian State Railways, Telegraphs and Telephones.

"THE EGYPTIAN RAILWAY ADVERTISER."

A weekly publication in Arabic, English and French.

Subscription: 50 Egyptian Piastres (about 10 shillings) yearly.

An organ of the Egyptian State Railways, Telegraphs and Telephones, containing information of interest to Contractors and Suppliers of Materials and Stores used by the Administration.

For particulars apply to PUBLICITY SECTION, Egyptian State Railways, Cairo (Egypt). 8085

SITUATIONS OPEN

WANTED, an Experienced ENGINEER, for a Chemical Works near London.—Address, stating age, training, and salary required, sending copies of testimonials, 8238, The Engineer Office. 8238 A

ARTICLED PUPIL.—A CHARTERED CIVIL ENGINEER has VACANCY for well-educated Youth as ARTICLED PUPIL; good practical and theoretical training. Interesting works in progress. Premium.—Address, 8061, The Engineer Office. 8061 A

ASSISTANT RATEFIXER WANTED for Machine Shop of large Electrical Engineering Works. Applicants must have had previous Ratefixing Experience, and be able to Estimate from Drawings.—Address, stating full particulars of experience, age and salary required, 8206, The Engineer Office. 8206 A

ENGINEER, Accustomed to Preparing Tenders for Turbine Plant and Power Station Equipment.—Address application, stating age, training, experience, and salary required, 8122, The Engineer Office. 8122 A

ENGINEER REPRESENTATIVE.—Well-known SUGAR MACHINERY MANUFACTURERS REQUIRE a REPRESENTATIVE (unmarried) for India. Must have had experience of making or designing, running and selling Sugar Machinery. Indian experience preferred, but not essential. Send full particulars of qualifications and experience.—Address, 8158, The Engineer Office. 8158 A

ESTIMATOR REQUIRED, Capable of Making Estimates from project drawings for Mechanical Handling Plants for coal and other materials. Only men with good experience and proved abilities need apply. State age, experience, and salary required.—Address, 8165, The Engineer Office. 8165 A

MACHINE TOOL SALESMAN WANTED for Large Firm in North of England; must be thoroughly practical and have good connection amongst large engineering firms. Applications should state fully the qualifications, experience and salary required.—Address, 8172, The Engineer Office. 8172 A

STRUCTURAL ENGINEERS WANTED by well-known Manchester Firm, to act as Resident Representatives in the cities of Birmingham, Leicester, and Sheffield. Preference to technical men with connections amongst architects and engineers. Salary and commission basis. Good prospects to right men.—Address, stating age and full particulars of experience, with references to recent employers, 8212, The Engineer Office. 8212 A

VACANCY Occurs in Large Works in the Midlands for well-educated ENGINEER, who has preferably a university degree and some works experience in fine Chemical Engineering Plant.—Address, stating age, experience, &c., 8210, The Engineer Office. 8210 A

WATER TURBINE ENGINEER REQUIRED in Hydro-electric Department of large Engineering Firm in London. Must be experienced in compilation of tenders and drawings. Good references essential.—Address, stating age and salary required, 8214, The Engineer Office. 8214 A

WANTED, a Thoroughly Capable DESIGNER to Undertake the Design of a Complete Range of Cylindrical and Surface Metal Grinding Machines. The position offers good prospects to a well-qualified person. State experience and salary required. Confidential.—Address, 8175, The Engineer Office. 8175 A

WANTED, CHIEF DRAUGHTSMAN. Progressive and permanent position for one who has ability to Direct and Control D.O. Staff, with experience and responsibility in connection with High-speed Passenger Lift Work. Only really able men need apply, giving full particulars of experience, and salary required, to R. A. EVANS, Ltd., Prospect-road, Leicester. 8199 A

WANTED, First-class DRAUGHTSMAN, Used to Light Railway Carriage and Rolling Stock and Vacuum Brakes. State age, experience and salary required.—Address, 8200, The Engineer Office. 8200 A

WANTED, First-class JUNIOR STRUCTURAL DRAUGHTSMAN, with good experience, preferably in London, of Steel-framed Building, Shop Detailing. Salary required to be stated.—Apply, "DRAUGHTSMAN," c/o Hay Fielding and Co., 45, Old Queen-street, S.W. 1. P181 A

WANTED, First-class LOCOMOTIVE DRAUGHTSMAN for Yorkshire; capable of Designing throughout.—Address, with particulars, salary, &c., 8201, The Engineer Office. 8201 A

WANTED, STRUCTURAL STEEL DRAUGHTSMAN; one used to Mechanical Handling Plants. State previous experience, age and salary required.—Address, 8202, The Engineer Office. 8202 A

DESIGNING DRAUGHTSMAN REQUIRED in connection with Coal and Mechanical Handling Plants. Only men with complete knowledge and first-class experience need apply. State age, experience, and salary required.—Address, 8166, The Engineer Office. 8166 A

DRAUGHTSMEN.—BEFORE NEGOTIATING with Government Departments in connection with any post, PLEASE COMMUNICATE with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 98, St. George's-square, London, S.W. 1. 7871 A

DRAUGHTSMAN, Experienced in Hydraulic and Electrical Work, for firm at Southall, Middlesex. State age, experience and salary expected.—Address, 8190, The Engineer Office. 8190 A

SITUATIONS OPEN (continued)

DRAUGHTSMAN. — First-class MECHANICAL DRAUGHTSMAN WANTED by firm in N.W. London. Only men with sound technical training and thorough practical experience will be considered. Good position for right man.—Address, stating age, experience, and salary required, 8164, The Engineer Office. 8164 A

DRAUGHTSMAN WANTED IMMEDIATELY in London, with Electrical and Mechanical experience, for Power Station and Sub-station Work. State experience, age, and salary required.—Address, P176, The Engineer Office. P176 A

DRAUGHTSMAN WANTED, Used to Refrigerating Lay-out and Machine Design. State experience and salary.—Address, 8174, The Engineer Office. 8174 A

DRAUGHTSMEN.—MORELAND, HAYNE and CO., Ltd., Constructional Steelwork Engineers, REQUIRE IMMEDIATELY TWO DRAUGHTSMEN. Only those fully able to Detail and Carry-out Jobs need apply.—Send particulars of age, experience, salary required, and when free, to SECRETARY, 80, Goswell-road, E.C. 1. P175 A

DRAUGHTSMEN (SEVERAL) REQUIRED in London Postal District W. 14; must be thoroughly capable men, having first-class experience in Arrangement and Detail of either Boiler Plant and Pipework or Cooking Apparatus and Allied Catering Machinery, or Heating, Ventilating and General Engineering.—Address, stating full particulars and salary required, to Box 305, Samson Clark and Co., Ltd., 57, Mortimer-street, W. 1. 8207 A

EXPERIENCED DRAUGHTSMAN REQUIRED, having knowledge of Hydraulic Turbines and Governors. Must be able to execute workshop drawings under guidance of designer.—Address, stating age and salary required, 8215, The Engineer Office. 8215 A

FIRST-CLASS DRAUGHTSMAN REQUIRED, with experience in Gasworks Coal and Coke-handling Plant.—Address, with full record of experience and salary required, 8188, The Engineer Office. 8188 A

REQUIRED by Large Engineering Firm in Midlands, a LEADING ENGINEER DRAUGHTSMAN for Internal Combustion Engines for industrial and marine purposes. Good scope for suitable man, who must also have some knowledge of Steam Engines.—Address, giving age, qualifications, and references, state when at liberty, and what salary required, 8126, The Engineer Office. 8126 A

REQUIRED IMMEDIATELY for India, STRUCTURAL DRAUGHTSMAN, age about 24-30. Must be competent work out stress diagrams, design Steel Structures, also all-round first-class constructional knowledge. Colliery plant experience an advantage. Salary Rs. 600 monthly, including quarters.—Write, stating age, experience, &c., to Box N.C., c/o Davies and Co., 95, Bishopsgate, E.C. 2. 8236 A

WANTED for Large Works in the Midlands, thoroughly experienced ENGINEERING FOREMAN, who has had extended knowledge and control of refined precision Chemical Engineering Plant, and who is well skilled in the maintenance and upkeep of this class of equipment, together with the control of labour. Good prospects for suitable man.—Address in confidence, stating age, experience, and salary required, 8211, The Engineer Office. 8211 A

WANTED, FOREMAN MILLWRIGHT: Must be fully experienced in upkeep of all grades of Mechanical Plant. State age and experience by letter only.—LAKE and ELLIOT, Ltd., Braintree, Essex. 8228 A

FOUNDRY FOREMAN REQUIRED for Important Argentine Railway; age 30-40, experienced in up-to-date Foundry Practice, including Iron and Brass Moulding, Machine Moulding, Cupola and Crucible Melting, Sand Mixing, Piecework and Ratefixing; able to handle 120 men, and should have working knowledge of Metallurgy and ability to learn Spanish. Salary, £550 p.a. on three years' contract, free passage out and home.—Apply, stating age and particulars of training and experience, with copies (only) of testimonials, to Box W. X. A., c.o. Davies and Co., 95, Bishopsgate, E.C. 2. 8193 A

SITUATIONS WANTED

B.Sc. (Eng.) (23) SEEKS SITUATION. Good draughtsman and leveller; 18 months civ. eng. experience. Low salary for a beginning.—Address, P188, The Engineer Office. P188 B

COAL CUTTING MACHINERY
FOR
LONGWALL, HEADING, SHEARING, RANGING, ARCING.

EXPERT, Who Has Designed and Organised, for two of the largest companies in Britain (well-known established machines covered by many patents), OFFERS SERVICES and NEW DESIGNS (patentable) for combination type with unrivalled application.—Inquiries in first instance to ENGINEERING PUBLICITY SERVICE, Ltd., Regent House, Kingsway, London. 8178 B

COSTS.—METHODS ADAPTED to INDIVIDUAL CONCERNS, organised on works lines.—Address, P131, The Engineer Office. P131 B

ENGINEER, Mechanical, Works Experience, Design and estimating, specialist textile machines, capable negotiating orders, some secretarial knowledge, fluent French, Italian and German. Age 32, good presence and education. WANTS POST with firm of merchants or others in London district.—Address, 8230, The Engineer Office. 8230 B

INSPECTION.
INSPECTING ENGINEER, A.M.I. Mech. E., Fully qualified, residing Stoke-on-Trent, UNDERTAKES INSPECTION of Locomotives, Railway Plant, Machinery and Materials in Midlands. Terms and further particulars, address, P191, The Engineer Office. P191 B

IRON, STEEL AND ENGINEERING SALESMAN.—Mr. J. PILKINGTON HUNT, having completed six years' engagement with Messrs. Hall and Pickles, Ltd., is now OPEN to DISCUSS the REPRESENTATION of a high-class FIRM in the Manchester and Lancashire area.—Confidential communications to be addressed c.o. The Engineers' Club, Manchester. 8107 B

MECHANICAL and ELECTRICAL ENGINEER, war service, experienced design and erection hydro-electric schemes, aerial ropeways, structural steelwork, general colonial engineering, estimating and correspondence, DESIRES POSITION, home or abroad.—Address, P173, The Engineer Office. P173 B

POSITION as MANAGER or ORGANISER REQUIRED by Engineer (42), experienced in management, organisation, and production of general engineering and mining plant, especially costing, estimating, and works accountancy. Competent to control staff and labour problems. Would like to know firm where proved ability is required in capacities mentioned.—Address, 8217, The Engineer Office. 8217 B

PUBLIC SCHOOL BOY, Age 21, SEEKS POST on Experimental or Testing Staff at good-class works. Good knowledge of electric testing, mathematics and practical chemistry; 2½ years' experience on testing staff at large factory.—address, P182, The Engineer Office. P182 B

SITUATIONS WANTED (continued)

RESIDENT ENGINEER, or to GET OUT CONTRACT PLANS assisted by draughtsmen. Docks, railways, bridges, tunnels, roads.—Address, P187, The Engineer Office. P187 B

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For continuation of Small Advertisements see page 3.

A Seven-Day Journal

New Fairfield Developments.

SOME time ago we announced that the Fairfield Shipbuilding and Engineering Company, Limited, had bought the Chepstow yard of the Monmouth Shipbuilding Company, Limited. The Fairfield Company is now in possession of the Chepstow establishment, which is to be developed in two sections. That section of the works known as Finch's Yard will still be used for shipbuilding, and will be known as the Chepstow Shipbuilding Works. At it the firm will build cargo vessels up to 240ft. in length and about 5000 gross tons, and small craft, such as barges and tugs, while marine constructional work, such as caissons and dock gates, will be undertaken. In the other main section of the works, which will be called the Chepstow Wagon and Constructional Works, a special plant has been laid down for the production of 20-ton all-steel wagons and tank wagons, for wagon repairs, bridge and roof work, and structural steelwork generally. In this connection it may be recalled that the Fairfield Company, along with James Howden and Co., Limited, of Glasgow, recently acquired the British rights for the Ruth type of steam accumulator. It is, we learn, quite likely that the steel accumulators themselves will be built at Glasgow and also at Chepstow, the special steam valves required being supplied by Messrs. Howden.

Oil Pollution in Coastal Waters.

FURTHER to our Journal note of last week on the subject of oil pollution, we are now enabled to state that the report of the Joint Committee of the Chamber of Shipping and the Liverpool Steamship Owners' Association on oil discharge, was adopted by the Council of the Chamber of Shipping at its meeting held on the 22nd inst. The chief recommendations of the Committee may be summarised as follows:—Any regulations dealing with the discharge of oil at sea should be agreed upon and enforced by all the maritime countries, and these regulations, moreover, should apply only to crude petroleum, boiler oil fuel and Diesel oil. The Committee further suggests that authority should be sought to prohibit the discharge of oily ballast water and tank washings by all vessels other than naval craft within 150 miles from the nearest coast, and it would be assumed that the naval authorities in all countries would impose similar restrictions on naval craft. With a view to enforcing any regulations which might be introduced, it should be made compulsory to record all pumping of oily ballast water and tank washings in the ship's log. A tribute is paid by the Committee to the good working of oil-separating barges, similar to that described in THE ENGINEER, January 26th, 1923, in the various ports, and it is recommended that such provision should be made in all ports used by oil-carrying or oil-driven vessels. The Committee regards the compulsory fitting of oil separators on vessels as undesirable, its view being that the existing types of separators are, speaking generally, capable of extracting oil from water and of discharging clean water into the sea, but that they are not capable of completely separating oil and water when in emulsion. The view is expressed that new types of separators will be evolved, capable of meeting the requirements, and developments will be watched with keen interest by shipowners.

A New Lifeboat.

A DEMONSTRATION was given in the Royal Albert Dock on January 22nd of the capabilities of a new type of ship's lifeboat designed by Mr. J. R. Fleming. In it the usual oars are dispensed with, and their place is taken by a screw propeller. The screw is driven, through gearing, by a set of eight levers conveniently placed along the boat, at each of which it is possible for two men to work. The reason why this system of propulsion has been adopted is the usual clumsiness of landsmen in handling oars, while no skill is required in working the levers. During the trials, which were witnessed by representatives of the Board of Trade, Lloyd's, the British Corporation and many shipping companies, the boat was loaded with forty-two persons, and eight men easily maintained a speed of 3 miles an hour in still water. By doubling the number of men at the levers, the speed was increased to 6 miles per hour. It is claimed for the arrangement that a boat so fitted can get away from a ship's side more expeditiously than is possible with oars, while none of the parts will be lost if the boat capsizes. It is said that the representatives of the shipping world were favourably impressed by the demonstration.

North *v.* Vickers.

ALTHOUGH the following matter is not one of technical interest, it so nearly affects the reputation of one of our greatest engineering firms that we think it is right to refer to it in these columns. During the hearing of *North and others v. Vickers Limited*, with the subject of which we need not deal, Sir John Simon, counsel for the plaintiffs, said: "My instructions are—and I very gladly comply with them—to say that so far as there was on the record an imputation of fraud against this great firm, I unreservedly withdraw it on behalf of the plaintiffs. . . . I would like to make it plain that, whatever the consequence may be, my instructions, which I have now before me, are to withdraw any reflection which would be injurious in the circumstances, and I think ought not to be brought, and which go by the name of fraud." Mr. Stuart Bevan, counsel for Messrs. Vickers, said in reply: "The charge [of fraud] has been made and withdrawn in the most unreserved words. I have nothing more to say about it, except that I am unaffectedly glad that the case is in the hands of Sir John Simon, who has seen fit to make this honourable withdrawal of charges, which, in my submission, should never have been made"; and Mr. Justice Fraser concluded the incident in these words: "Everybody, I am sure, must be glad to hear the statement such as Sir John Simon has made, which entirely clears up the position and shows that there is really not the slightest foundation for a charge of fraud against the firm."

Submersible Cruisers.

THE submarine X.1 arrived at Portsmouth last week from Chatham, having completed a series of trials, and will probably join the Fleet before long. Her leading dimensions, as published, are as follows:—Length, 350ft.; beam, 29½ft.; draught, 17ft.; displacement, 2780 tons on the surface, 3600 tons submerged. Her speed appears to be high, but as the actual figure has not yet been officially announced no good purpose would be served by reproducing the unauthorised statements which have appeared on this subject. From a photograph issued to the Press, the new submarine, which is the largest in the world, appears to possess several remarkable features, apart from her imposing size. She is equipped with two turrets, each containing a pair of medium-calibre guns, one turret being placed before and the other abaft the conning tower. Owing to the comparatively lofty freeboard of the vessel the guns are mounted at a height that should keep them clear of water in most conditions of weather, a circumstance which adds greatly to their military value. Hitherto the utility of guns in submarines has been prejudiced by their low position, only a few feet above the water, where it is practically impossible to work them in rough weather or when the boat is steaming into a head sea. The artillery of the X.1 is free from this defect, mounted as it is at a height but little inferior to that of the guns in the average small cruiser. Provided the turrets, the conning tower, and the exposed portion of the hull are armoured, the vessel ought to prove a formidable opponent to the smaller types of surface men-of-war, while against a more powerful enemy she could use her torpedo tubes, the number of which has yet to be revealed.

The Suez Canal Traffic.

As one of the indications of the flow of trade between Europe and the Far East, the traffic returns of the Suez Canal are always of interest. To no country are they of greater importance than to Great Britain. Not only do more ships flying the British flag pass through the Canal than ships of all other nationalities combined, but the largest shareholder in the Canal Company is the British Government. The new records set up during 1924 can, therefore, be regarded as highly satisfactory. Last year a total of 5121 vessels passed through the Canal, with a total net tonnage of 25,109,921 tons. This tonnage, compared with an aggregate of 22,730,162 tons for 1923, shows an increase of 2,379,759 tons, or about 10 per cent. The greatest increase took place in the last three months, when the total tonnage and the increase were 6,920,742 tons and 1,173,765 respectively. An idea of the relative volume of shipping using the Canal can be obtained by comparing it with the tonnage entered in 1924 at London, 15,132,254 tons, and Liverpool, 11,194,192 tons. The value of the Suez Canal shares held by the British Government is assessed at £22,416,737.

Control of Large Submarines.

IN view of the great length and enormous weight of the X.1, it is not to be expected that she will prove as easy to manipulate as our smaller submarines. Even the "K" and "M" boats, which are several hundred tons lighter, require very careful handling when in diving trim, and officers and crew have to be more than ordinarily proficient in their duties. In the case of X.1, no doubt, every mechanical contrivance necessary for the control of trim and buoyancy is installed. Both in dimensions and appearance she recalls the submersible cruisers which Professor Oswald Flamm, of Charlottenburg, claimed recently to have designed on a new principle of stability. Of his two projects, the first was for a submersible of 4000 tons, and the second for a "diving cruiser" of more than 7000 tons. In each case the armament was to consist of heavy guns disposed in turrets, and a great deal of protective armour was to be carried. When announcing his plans the professor took occasion to cast doubt on the skill of British submarine designers, alleging that the problem of endowing large submarines with the requisite degree of stability when in a submerged condition still baffled them, a problem which he claimed to have solved. Be this as it may, the completion of the X.1 provides visual proof of the technical skill and enterprise of our Admiralty constructors. Another large submarine, the V.2, was launched for the United States Navy last month. She is 341½ft. in length, displaces 2164 tons on the surface, and is propelled by four Diesel engines of 6500 horse-power at a speed of 21 knots. Her armament comprises one 5in. 51-calibre gun and six 21in. torpedo tubes. She has a complement of eighty officers and men. France, we may add, is building two submarines, Vengeur and Redoutable, each with a submerged displacement of 3000 tons.

French Exports.

THE failure of the French to negotiate a treaty of commerce with Germany has created a situation which may possibly influence international trade in the early future. An inquiry amongst the different branches of industry particularly affected by the closing of the German market shows that manufacturers are resigned to the necessity of carrying on a vigorous competition abroad, for the country cannot possibly absorb all the products from Alsace-Lorraine and from those industries which have practically lived on exports to Germany during the period when it was bound by the economical clauses of the Versailles Treaty. So long as Germany is obliged to supply coke for reparation the production of iron and steel can be maintained, but a large proportion of the material must go abroad, and as it cannot be sent to Germany with the present prohibitive tariffs it is rumoured that negotiations have been in progress for consigning steel to the United States. Despite the huge disparity in money values in the two countries, it is doubtful whether a market can be found in America for French metallurgical products, but the fact that such a possibility is contemplated shows that the French are convinced of being able to dispose of goods in countries with a normal currency.

French Public Works.

THE report that American financiers have decided to postpone the issue of French industrial and municipal debentures in the United States until such time as some definite pronouncement is made concerning the repayment of the French debt to that country points to complications that may have serious consequences for the French engineering trades. The money is required to carry out the vast programme of public works, including the canalisation of the Rhone and the construction of hydro-electric installations providing nearly 400,000 horse-power between Geneva and Lyons, as well as the irrigation of a million and a-half acres of arid land traversed by the lower part of that great waterway. It was known that American financiers were willing to supply a large part of the capital required on condition of their being allowed to take an active part in carrying out the enterprise. The municipal councils of Paris and other towns had arranged for the issue of debentures in the United States to permit of their putting urgent public undertakings in hand. The suspension of the negotiations will certainly delay the execution of the works and will cause some embarrassment to French industry, which had relied upon them for a recovery of activity. Additional engineering enterprise is all the more necessary now that it has been decided to stop further reconstruction work in the devastated regions because the Government is able this year to provide only a quarter of the amount allotted for the purpose in 1924. The Government wants to pay the remainder in bonds, which the contractors refuse to accept. Unless something is done to ensure the carrying out of these undertakings the situation of the French engineering trades during the present year threatens to become precarious.

Wireless Transmitters.

A STATEMENT on the position of the amateur wireless transmitter in relation to the broadcast listener was recently made by Mr. H. Bevan, the chairman of the transmitter and relay section of the Radio Society of Great Britain, in a speech broadcast from "2 L O." The holder of a transmitting licence, he said, enjoyed the privileges granted by the Postmaster-General to carry out experimental work upon a fixed wave length of 440 m., a band from 150 to 200, and in a few cases upon extremely low wave lengths. As the 440 m. wave length was within the broadcast, band transmissions on that wave length were prohibited during broadcast hours, but there were no restrictions relating to the lower wave lengths, and the experimenter was therefore free, within the terms of his licence, to work during any hours. The majority of transmitters, however, made it a strict rule never to work during the hours of broadcasting, because they knew that the unselective receiving sets surrounding them would pick up the emitted waves. Although the amateur transmitter was often blamed for the interference experienced by users of receiving sets, interference was mainly due to Morse messages sent to ships or to high-power coastal stations, coupled with the fact that the average receiving set was hopelessly unselective. The trouble would be minimised if more use was made of the coupled circuit, as advocated by Captain Eckersley.

The British Steam Railway Locomotive from 1825 to 1924.

By E. L. AHRONS, M.I. Mech. E.

No. V.*

PERIOD 1837 TO 1841.

IN dealing with this period, it is proposed to follow the development of the standard gauge engines of the Hackworth, Bury, and Stephenson schools, and also give some account of the broad-gauge engines of the Great Western Railway, which was opened in 1837. The narrative will be rendered more intelligible by dealing with each of the locomotives separately without regard to chronological order.

Hackworth's Mineral Engines, with Inclined Cylinders.—In 1838 Hackworth abandoned vertical cylinders and "dummy" crank shafts for his 0–6–0 mineral engines, and reverted to the direct drive of the Royal George, but placed the cylinders at the back end of the boiler, to which they were attached in a position inclined at about 30 deg. The connecting-rods worked on crank pins in the front wheels at the chimney end of the engine. The illustration—Fig. 25—shows one of this class for the Stockton and Darlington Railway, which had 4ft. wheels, 9ft. wheel base, and 14in. by 18in. cylinders. Some of the earlier engines of the class had cylinders 12½in. diameter, and in later engines, of 1842, 14½in. by 20in. The boilers, in which the pressure was increased to 70 lb., were of the "outward" flue and return multitubular type previously described.

It seems likely that Hackworth's reason for introducing this design was to have an engine with springs for each axle, and at the same time do away with the awkward vertical cylinder drive of the "Wilberforce" class. But in making the change he merely reverted to Stephenson's old type of 1828, as exemplified by the "Lancashire Witch." A considerable number of these engines were designed by Hackworth for the Stockton and Darlington Railway, and were built, not only by him at Shildon, but also by the two Darlington firms of W. and A. Kitching and William Lister. They were the last designed by Timothy Hackworth for the Stockton and Darlington Railway, though his influence was apparent in some of the later engines of the company, which will be mentioned subsequently.

It may be asked why Hackworth, having seen the advantages of horizontal cylinders for passenger engines, did not use them for his mineral engines. In 1838 the only engines with outside horizontal cylinders were the passenger engines by Forrester, with their awkward outside frames, a type which no other designer in this country desired to perpetuate. Two inside framed 0–4–2 engines, to be mentioned subsequently, were built in 1839 for the London and Croydon Railway, and they appear to have been the first definitely known to have combined outside horizontal cylinders, with coupling-rods on the leading wheels. Had Hackworth adopted a similar design with six coupled wheels, he would have had to alter completely the design of the framing of his engines. But he was not alone in discarding the idea, if he ever considered it, for it is a remarkable fact that British locomotive engineers have always avoided the outside cylinder 0–6–0 tender engine, universal on the European continental railways, and less than fifty, all told, have ever run on British railways throughout their history.

Bury's Bar-framed Locomotives.—The general design of Bury's engines remained as before, with improvements in details, and only four-wheeled engines were built. The type was also taken up by Braithwaite and Milner, of London, who built a number for the the Eastern Counties Railways and American railways. Although it adopted most of the features of Bury's design, the London firm generally used round-topped ordinary type fire-boxes, surmounted by domes, and discarded Bury's D-shaped pattern.

For a number of years Bury used iron for fire-boxes. The D-shaped fire-boxes were welded at the front corners up to a level with the bottom row of tubes. He eventually used copper, but the writer can find no record of the date of this change, though it was certainly some time after Stephenson had discarded iron for copper in 1832. In 1837 Edward Bury took charge of the locomotive department of the London and Birmingham Railway, and immediately introduced his four-wheeled type of engine. By the end of 1841 there were 58 passenger engines of the 2–2–0 type

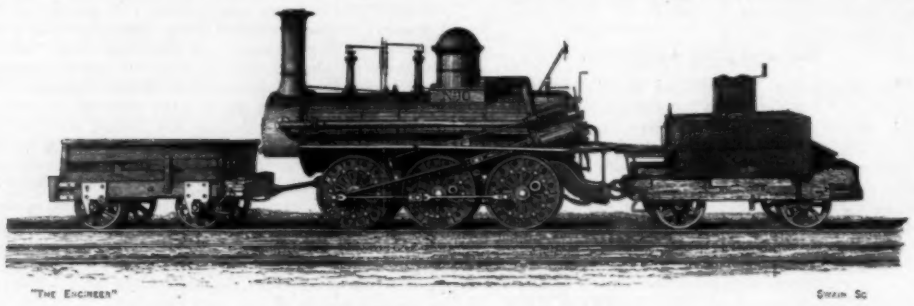

FIG. 25—HACKWORTH'S 0-6-0 ENGINE, 1838

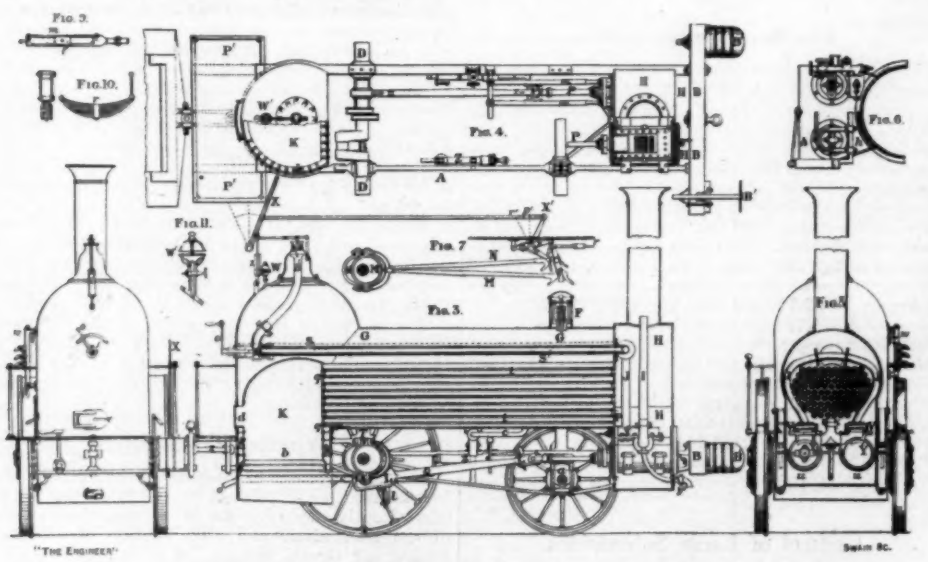

FIG. 26—SECTIONS OF BURY'S 2-2-0 PASSENGER ENGINE, 1837

—Fig. 26—and thirty goods engines of the 0–4–0 type on that railway. Other lines, such as the Manchester and Bolton, North Union, and Midland Counties railways, adopted the four-wheeled type practically exclusively, and the Edinburgh and Glasgow Railway and other railways had a large number. On the other hand, the Liverpool and Manchester Railway, after experience with four-wheeled engines, had converted most of them to six wheeled, and other important main lines, such as the Grand Junction, North Midland, &c., would not even look at the four-wheeled type. There resulted for a time a "battle of the wheels," and the circular issued by Bury, Curtis and Kennedy—referred to previously—had for its main object the putting forward of arguments in favour of the four-wheeled engine. Bury contended that it cost less, and the total weight being less, less power was required to take it up the inclines. It was safer and not so liable to leave the rails on curves; there were fewer parts and consequently less friction and less liability to break down. His best argument was based on the smaller size of turntables and engine sheds required. There were two arguments in which Bury certainly went astray. In order to reduce the overhang at the trailing end, he advocated small fire-boxes, and, short as these were, the heating surface was still further reduced by their semi-circular D shape. He also tried to minimise the danger in case one of the two axles broke, and in his evidence before the Gauge Commissioners in 1845 stated that on the London and Birmingham Railway there had been no case of an engine so far crippled by a broken crank axle that it could not get home; in fact, some of them had taken their trains on in spite of the broken axle. He admitted that one engine had left the rails owing to the breakage of a leading axle. But nothing appears to have been said on the subject of a bad accident in 1841 on the Brighton line and another in France, in which Bury's engines left the rails. It should also be added that Bury tried to minimise the unsteadiness of his four-wheeled engines by coupling the tender as rigidly as possible to the engine. The four-wheeled engine was too small, and it was not unusual on the London and Birmingham line to work the goods trains with four of Bury's engines attached, and he admitted before the Gauge Commissioners that on one occasion no less than seven engines were required during a heavy gale for a train of forty-five wagons.

In 1845 Bury bowed to the inevitable and began to build six-wheeled engines. It was not the general design, other than the use of inside frames, which had pulled his four-wheeled engine through for so long, but the undoubted excellence of the workmanship which his firm put into the engines.

The 2–2–2 Passenger Engine.—The Stephenson 2–2–2 type with inside cylinders and outside sandwich frames had proved itself to be an efficient machine, and was, in effect, a "survival of the fittest." During the period 1837 to 1841 various locomotive builders added their own ideas, and the details of the engines began to exhibit the individualities of the various firms. For the purpose of contrasting these types, the six illustrations—Figs. 27 to 32—are given. The first figure represents the North Midland mail engine, which was built from R. Stephenson's drawings by various firms. All the examples have some general features in common. The cylinders in most cases were 13in. by 18in., and the driving wheels 5ft. 6in. During 1840–1 many were built with 14in. by 18in. cylinders for heavier traffic and steeper gradients. Such were the North Midland "Mail" engines—Fig. 27—which had 6ft. driving wheels. The heating surfaces varied somewhat, but the mean was about 500 to 550 square feet for the tubes and 50 to 55 square feet for the fire-boxes. The average boiler pressure was about 60 lb., but was raised to 70 lb. in some of the later engines of 1841–2. The framing was on the principle of Stephenson's engine "Harvey Combe," previously described, the smoke-box and boiler being secured by brackets to and supported by the outside sandwich frames, but the inside frames extended only from the back of the smoke-box to the front of the fire-box. The driving axle had at least four bearings and frequently five or even six.

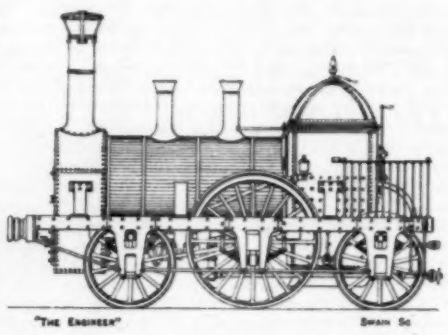

FIG. 27—STEPHENSON TYPE 2-2-2 ENGINE

One of the early difficulties met with was water in the cylinders, owing either to direct "priming" or to leakage into the internal steam pipe through the joints. Measurements made in France on locomotives by British makers of the 1834–1840 period showed that in the earlier engines the total boiler content was about 55 cubic feet, of which the steam space occupied about 18.6 cubic feet. In the later engines of 1839–40 the boiler content had—according to Flachat and Petiet—increased to about 81½ cubic feet, and the steam space to 23 cubic feet. The want of sufficient steam space in the earlier engines caused priming, and this accounts for the variety of domes and steam chambers in the illustrations. Messrs. Stephenson—Fig. 27—did away in 1840 with the steam dome on the barrel, and made the fire-box casing with a vaulted roof, as Bury had already done for some years with his smaller fire-boxes. This type was constructed by Stephenson, Kitson, and other makers for about eight years, and it was also adopted by Gooch on the Great Western Railway. The top of the casing was of a somewhat pointed pyramidal shape, owing to the way in which the side

* No. IV. appeared January 23rd.

and end sheets were cut and brought together, and gave rise to the term "Gothic" fire-boxes. Bury's fire-box casings had rounded corners, and were either hemispherical or slightly flattened on the top, the latter type being known as "haystacks." The two were frequently confounded. A large number of hemispherical fire-box casings were also made by Stephenson from 1842 onwards; they required less staying than the Gothic pattern, in which the surfaces of the dome were flatter.

Tayleur and Co.—Fig. 28—and Mather, Dixon and Co.—Fig. 29—increased the steam space in another way by providing two domes. The one above the fire-box was merely a steam vessel, the other near the chimney contained the regulator. This was also the practice on the Liverpool and Manchester Railway. Rothwell and Co.—Fig. 31—and Sharp Roberts—Fig. 32—contented themselves with raising the fire-box casing and providing a tall dome behind the chimney. A 2-2-2 engine by G. and J. Rennie (London)—illustrated in THE ENGINEER,

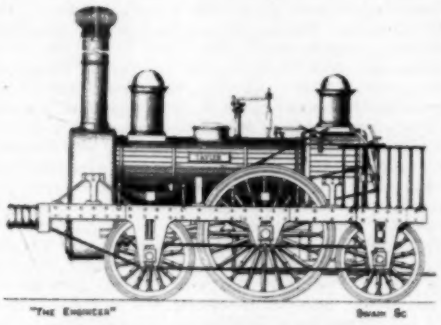

FIG. 28—TAYLEUR TYPE 2-2-2 ENGINE

April 8th, 1921, page 367, in elevation and section—is another example of this practice. The forward position of the dome was supposed to have as its principal object the placing of the regulator as far as possible from the fire-box where the most violent ebullition took place, but there were other equally cogent considerations. Long steam pipes were then made with joints and glands, which caused leakage when the water level was high, and to avoid this trouble, the pipes in the designs under consideration were made as short as possible. Moreover, with the short steam pipe, the steam space in the boiler was not occupied. On the other hand, when the dome was situated in front, it had the disadvantage of throwing some extra weight on the leading wheels, and in the old 2-2-2 type the trailing pair was, if anything, too lightly loaded. Messrs. Hawthorn—Fig. 30—compromised by placing the dome on the middle of the barrel, a position to which they had consistently adhered. W. and A. Kitching's 2-2-2 engine, Raby Castle, for the Stockton and Darlington Railway—

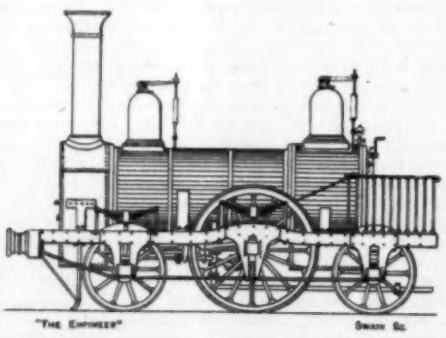

FIG. 29—MATHER, DIXON TYPE 2-2-2 ENGINE

THE ENGINEER, October 29th, 1920, page 420—was similar.

Boilers.—Owing to the small sizes of plates, a large number were required for the boilers. Warren records that a "Planet" type boiler in 1831 then require no less than twenty-two plates. According to a specification for new boilers for the Liverpool and Manchester Railway, dated October 1838, the barrels were to be made of four narrow Low Moor iron plates, each the full length of the barrel, that is, about 7ft. 6in. to 8ft. The plates were lap jointed with longitudinal seams only. Thus the material worked under the worst conditions, for not only were there four longitudinal lap seams in boilers such as were specified by the Liverpool and Manchester Railway, but the grain of the iron was placed so that the maximum stress acted across it. For 50 lb. pressure, $^5/_{16}$in. plates were usual, but the front tube plate was $\frac{7}{16}$in. thick. Rivet holes were punched, but care was taken that the plates were assembled so that the smaller diameters of the holes were inside the joint. The writer has not been able to find any record of rimering out rivet holes at this period. The tubes were usually of brass, but iron had been used. Sir J. Hawkshaw used iron fire-boxes and iron tubes on the Manchester and Bolton Railway, but had trouble with the fire-boxes.

Boiler clothing may be briefly mentioned here. Until about 1838–9 it was usual to clothe the barrel with strips of wood lagging, but the fire-box casing was generally left bare. From that date several firms began to clothe the lower part only of the casings, also with wood battens, though the engines by Sharp, Roberts, and Mather, Dixon—Figs. 32 and 29—of 1839 show completely clothed fire-boxes. Stephenson's engine—Fig. 27—is shown without clothing on the casing, as in the original drawing, but it is not certain whether the latter was a conventional drawing-office method of showing the fire-box, and it is possible that in 1840 the lower portion at least was lagged, as in the Great Western engines then built by the same firm.

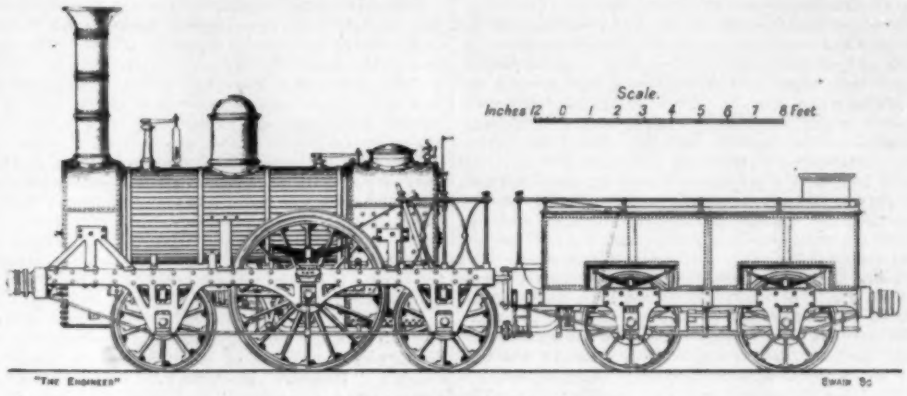

FIG. 30—HAWTHORN TYPE 2-2-2 ENGINE

The wooden battens were tenoned and grooved, and finished by being stained and varnished. Subsequently, a layer of felt was placed beneath them, but the experience of several years proved that rain got between the joints and damped the felt, so that about 1847 sheet iron covering began to replace the wood. E. B. Wilson and Co. continued the use of polished mahogany battens until about 1851.

Fire-box Roof Stays.—In some of the very early engines of 1830–1 the roof stays consisted merely of four short angle iron stiffeners, secured to the middle portion of the fire-box crown, without extending to the tube and back plates. In 1835 Messrs. Stephenson substituted iron girders for the angle bars. These girders had projections at intervals which rested upon the roof, but they still remained shorter than the full length of the box. Some of Bury's earliest engines of 1831–3 had dome-shaped spherical crowns without any roof stays; but when he introduced the D-shaped fire-box in order to increase the heating surface, the front half of the dome was flattened, and to strengthen it four small girders were used, the back ends of which simply rested on the curved back portion of the roof without other support.

Stephenson's North Midland engines of 1840, illustrated by Warren, had girders extending over the laps of the tube and back plates, though they did not take a bearing on the vertical sides. Some makers neglected to make the girders long enough, and when the roof gave way, as actually happened in the case of certain explosions, the girders were forced bodily

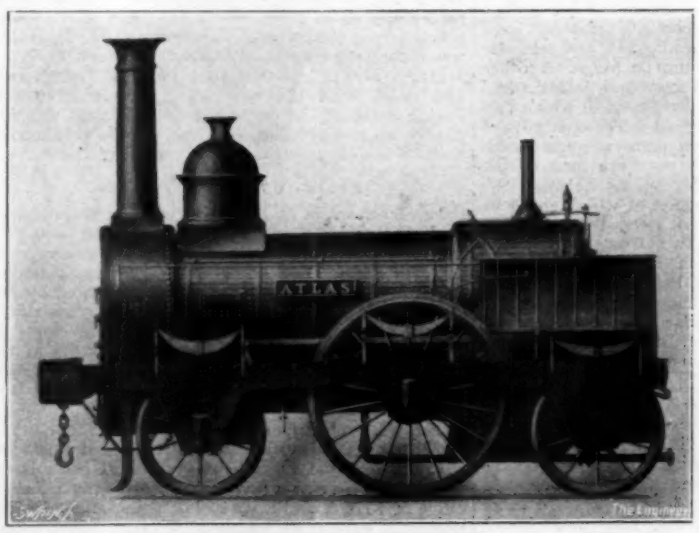

FIG. 32—SHARP ROBERTS TYPE 2-2-2 ENGINE

through into the fire-box. This also occurred in the case of a Bury fire-box provided with the short girders described above.

Side stays for some years were of iron, screwed through both plates. Warren states that they were riveted over outside the casing, but had nuts inside the fire-box. W. P. Marshall, in his description in Tredgold's "Steam Engine," of Stephenson's 2-2-2 engine of 1835–6, states that $\frac{7}{8}$in. screwed copper stays were then used, riveted over outside both plates.

Boiler Fittings.—The boiler fittings and accessories differed little from what they now are. There were the usual water level gauges with shut-off cocks, wash-out holes, blow-off cock, and fusible plugs. In most cases there was a lock-up safety valve, spring loaded, and arranged to blow off at a pressure slightly greater than the working pressure, which was regulated by the spring-balance safety valve. These details are mentioned to show the great progress made during the few years that locomotives had been in existence. There was, of course, no dial pressure gauge, and the driver had to depend upon the "feel" of his spring balance, which in some cases was inconveniently placed on the middle of the boiler.

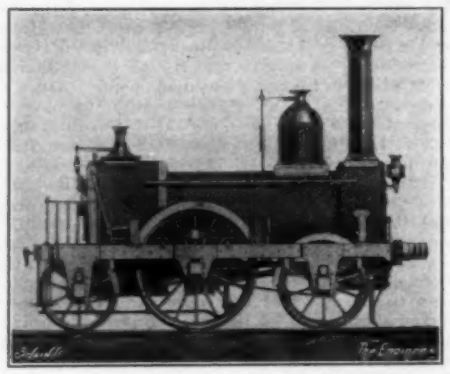

FIG. 31—ROTHWELL TYPE 2-2-2 ENGINE

In such of Stephenson's engines as had the dome over the fire-box the steam pipe was in one length from the smoke-box to an enlarged regulator chamber underneath the dome, and the pipe entered this chamber through a gland which allowed for expansion. Bury used a similar pipe, with a flanged joint, for the regulator chamber, but no gland. Fenton Murray and Jackson, in their earlier engines, made the steam pipe in flanged lengths, but with allowance for expansion at the front end, where the two copper pipes to the cylinders branched off from bends attached to the main pipe inside the barrel, each branch passing independently through the smoke-box tube plate.

The greatest difference lay in the regulators, of which there were many varieties. The slide valve gridiron regulator in the dome was then unknown, but it is not certain whether some firm—unknown to the writer—did not try a slide valve regulator in the smoke-box. Most of the regulators then in use were of the rotating disc valve type, with two sector-shaped apertures, which when open coincided with similar openings in a facing on the steam pipe chamber. R. Stephenson and Co. were amongst the first, if not actually the first, to use this type, and it appears in their engines of 1835. Tayleur used a more complicated regulator on the same principle, but placed it in the smoke-box, whereas in many of Stephenson's

engines it was at the fire-box end of the steam pipe. Fenton, Murray and Jackson in 1839 used a double beat valve, which was placed in the vertical steam pipe immediately under the dome. The movable portion of the valve was attached to a frame, which was lifted by a tappet attached to the regulator spindle. It was probably one of the best regulators of that day, and certainly the easiest to open, but it was difficult to keep steam tight, though in this respect the disc valves were very far from perfect.

Bury, judging from the number of designs which he introduced and almost as quickly discarded, seems to have had considerable trouble with his regulators. In his early engines he fitted the T pipe joining the main steam pipe and the vertical pipe from the domed fire-box casing with an ordinary conical plug cock attached to the regulator spindle. There was excessive friction, and as the plug expanded it frequently would not open when closed, or close when opened. The driver was supposed to grease it in the shed by removing the spindle gland. Bury's next and improved regulator was extremely ingenious as a mechanical contrivance, but still more unpractical. The regulator spindle was fitted with a long collar, which rotated inside a box. The latter had two pins let into it, which engaged in a spiral groove cut in the circumference of the collar, so that as the spindle and collar were rotated by the regulator handle the box and mitre valve attached to the latter received a longitudinal movement and opened the valve. The arrangement required cleaning and lubricating very frequently, to do which a man had to enter the boiler. Moreover, since it had a tendency to shut automatically, the driver had to keep his hand on the regulator handle.

A third design, illustrated by D. K. Clark, page 223, consisted of a horizontal double-beat valve actuated by a double-threaded screw.

Before 1840 Sharp, Roberts improved the Stephenson disc regulator by placing it in the dome, and actuating it by a double lever and vertical links. This type was used for many years. This regulator has always been credited to Sharp, Roberts, but Rothwell's engines of 1838 for the L. and S.W.R. were fitted with it. It may be that Rothwell used Sharp's design, which in that case was made before 1838.

Frames.—The shape of the outside framing of Sharp, Roberts's engine—Fig. 32—differs from most of the other designs, and was adopted to avoid the deep hornplates for the carrying axles necessary when the top of the frame is horizontal. The latter had a tendency to spring laterally. Sharp's design, which first appeared in 1837, was afterwards copied by nearly all other manufacturers, and a similar one is seen in Mather, Dixon's engine—Fig. 29—with the difference that Sharp, Roberts welded the axle guard plates to the body of the frame, whereas Mather, Dixon and others bolted them on. But all the designs show the defect of binding the boiler too rigidly to the frames.

In 1839 Isaac Dodds, locomotive superintendent of the Sheffield and Rotherham Railway, fastened his boiler at the smoke-box end only, and allowed it to slide on the frame at the back. A small plate or bracket bolted to the frame prevented the boiler from lifting—see "A Story of Railway Pioneers," by Major Snell.

The Stephenson engines—Fig. 27—had underhung driving springs, as in the "Planet," but the leading and trailing springs were of the double elliptical form, which for a few years was extensively used by R. Stephenson and Co., but afterwards disappeared for a long time from British practice.

Motion Details.—The Stephenson pistons have already been described in Section II., and metallic rings had superseded the old hemp packings. Another form of piston by Fenton, Murray and Jackson had a wide groove turned in the periphery, in which two brass rings were placed side by side. These rings were cut in two and the abutting ends were bevelled. As the rings wore down, wedges were forced from the inside into the triangular spaces between the ends by bent springs, the tension of which could be regulated by screws. Thus each complete ring had its tension controlled by two wedges, and the joints were staggered. With these pistons there was danger of the wedges being forced too far through and scoring the cylinders. A three-wedge metallic piston ring on similar lines was used by Isaac Dodds in 1831. Bury and Forrester used four segments for each of the two rings, with wedges between each pair.

After 1840, until superseded about 1857 by Ramsbottom's rings, one of the best pistons was Goodfellow's, used on Sharp's and McConnell's engines. It had two broad brass packing rings side by side. The inside of the joint between them was machined out to a V-shaped recess, into which a third inner wedge-shaped cast iron spring ring was fitted. The latter had many rectangular notches right round its outer periphery. These notches were deep at the ends of the ring and diminished gradually to nothing in the middle. By this means the pressure was equalised round the circumference. This appears to have been the earliest application of a locomotive piston in which the elasticity of a ring without the aid of independent springs and wedges was used to obtain steam-tightness. The piston is illustrated in D. K. Clark's "Railway Machinery," page 215.

Connecting-rod ends were usually of the gib and cotter type, in most of which the cotters had to be hammered in. Stephenson's big end was an improvement in that the cotter had a screwed extension, which passed through a lug on the gib, so that the cotter could be drawn up by means of nuts above and below the lug. This cotter was not so liable to shake loose, but many of the others were precariously held by a single set screw. The brasses were usually polygonal.

Sharp, Roberts's design was in advance of the period. The brasses were rectangular and regulated by a single cotter secured by three set screws. The front end of the strap was secured to the body of the rod by two dovetailed keys and a bolt. Whether this was the earliest use of the bolt which is seen in all modern strap ends the writer cannot say. The sharp angles of the keys were the weak point in these rods.

The exhaust passages of Sharp's engines of 1839–1842 were peculiar. Both exhausts were discharged from the cylinders into a cubical box placed midway between the inside cylinders, and the blast pipe was connected to the top of this box, which was intended to act as a form of "air vessel" to equalise the blast. It caused considerable back pressure in the cylinders.

Very little need be said about the many varieties of gab motion valve gears, since illustrations and descriptions of most of them are given in D. K. Clark's "Railway Machinery." Until 1840 the motion was "indirect," and rocking shaft levers were interposed between excentric rods and valve spindles. The valve gear with separated fore and back gear excentrics was similar to that of Stephenson's engine, Fig. 16, described previously. The evolution of the valve gears used by R. Stephenson and Co. leading up to the link motion is well described by Warren in Chapter XXVII. At the end of 1841 Messrs. Stephenson began to place the steam chest between the cylinders with almost vertical valve faces, and introduced a much simpler gab motion gear to give a direct motion to the valves (D. K. Clark, Fig. 34, page 24).

Radial valve gears without excentrics by Melling and by Hawthorn also made their appearance, but seem to have been little used. The valve motion was derived from a point near the middle of the connecting-rod as in Joy's gear. The engine shown in Fig. 30 had Hawthorn's gear, which is illustrated in D. K. Clark's "Railway Machinery," page 23, Fig. 33.

Miscellaneous Details.—W. Tomlinson in his history of the North-Eastern Railway records that the first sanding apparatus was used on the Newcastle and Carlisle Railway in 1838. The following year, W. Hawthorn brought out a "railway engine protector" to clear the rails from obstructions, and Whishaw specially mentions that all the engines on the railway mentioned in 1840 had "ploughs" in front of the leading wheels.

Institution of Mechanical Engineers.

LAST FRIDAY, at the Institution of Mechanical Engineers in London, two interesting and important papers dealing with the fundamental phenomena associated with the cutting action of tools were presented. Both papers were reports to the Institution's Cutting Tools Research Committee. One by Dr. T. E. Stanton and Mr. J. H. Hyde, of the National Physical Laboratory, described an experimental study of the forces exerted upon the surface of a cutting tool. The other was contributed by Dr. W. Rosenhain and Mr. A. C. Sturney, also of the National Physical Laboratory, and dealt with the flow and rupture of metals during cutting. It may thus be said that the two papers were devoted respectively to the engineering and the metallurgical aspect of metal cutting.

FORCES ON A CUTTING TOOL.

In Dr. Stanton and Mr. Hyde's paper the forces dealt with were those which arise in the case of a perfectly sharp tool before it has suffered any appreciable blunting. The object of the research undertaken was to investigate a problem suggested by Mr. William Taylor mainly to discover the extent to which the frictional and abrasive forces, developed in the action of cutting, are important factors in the complete operation. In the course of the work certain other important characteristics were revealed and investigated.

The work and tool are represented in Fig. 1. The work was a tube machined to an inside diameter of 1.625in. and a thickness of 0.10in. The tool was of a simple side cutting type, with a constant clearance angle of 10 deg. and a variable cutting angle θ. The problem was thus reduced to the measurement of the vertical and horizontal forces on the tool. The tools used were constant as to composition and heat treatment. No cutting lubricant was used.

The dynamometer employed consisted of a tool holder mounted on knife edges and other pivots in such a way as to transmit the horizontal and vertical forces on the tool through diaphragms to Bourdon gauges. The hydraulic medium used was oil. The dynamometer was calibrated by means of dead weights. The materials tested ranged from nickel-chromium steel with a Brinel hardness of 275 to copper of 83 hardness number. The procedure of the test consisted of setting the feed at a given value and, after, a period allowed for the assumption of steady conditions, of taking readings of the pressure gauges. Before repeating the test at a different feed the cutting surfaces of the tool were honed, great care being taken during the honing to preserve the angle of the tool at its original value.

The subject under investigation was studied by resolving the horizontal and vertical forces observed into forces at right angles to and parallel with the top rake surface of the tool. In Fig. 2 typical curves are given for three of the materials tested. The normal and tangential forces are here shown plotted against the cutting angle, θ Fig. 1, which alone was varied. The feed during the experiments represented by this diagram was constant at 0.01in. per revolution, and the cutting speed was also constant at 13ft. per minute. It will be seen that the tangential force is roughly independent of the cutting angle. The normal force, on the contrary, decreases rapidly as the cutting angle is made smaller, with definite evidence of reaching a limiting value at some low value of the cutting angle. Similar characteristics were found for cast iron, copper and brass, but in the case of a 0.5 carbon steel cold worked for use as hydraulic tubing it was found that the tangential force varied almost to the same extent and in the same manner as the normal force. When this material was normalised by heating it for half an hour at 850 deg. Cent. and cooling it in air the abnormal characteristic of the tangential force disappeared, this force becoming, as in the other materials, practically independent of the cutting angle.

Proceeding to analyse their experimental results, the authors reviewed the conditions under which a chip is removed from the work. Their conception of the action involved is represented in Fig. 3 Here O B is the top rake surface of the tool making an angle φ with the direction of motion, and O A is the trace of the plane along which the chip shears, which plane makes an angle α with the direction of motion. It is commonly assumed, they state, that the angle α is constant for ordinary materials, and in their analysis they take it to be approximately 26 deg. The cutting action, according to the authors, may be regarded as consisting of two operations:—(*a*) An indentation by the nose of the tool to a depth O O′ such that shearing along O′ A′ parallel with O A eventually takes place; and (*b*) a sliding of the material of the chip along O′ A′ giving rise to internal friction, which may result in the complete detachment of the chip from the stock in the case of large cutting angles, or in partial detachment with bending in the unsheared portion accompanied by sliding over the top rake surface of the tool.

By making certain assumptions and relying on results obtained by Hankins on the intensity of pressure produced by indenting tools the authors arrived by calculation at the values of the normal and tangential components of the indenting forces. Comparing these calculated values with the observed normal and tangential forces on the tool, they argue that the difference revealed is a rough measure of the magnitude of the forces due to the internal friction of the metal in the shaving. They conclude that the internal friction is the prime cause of the loss of work incurred by the use of large cutting angles.

Dealing with the effect of the friction of the shaving on the top rake surface of the tool, they examine Mallock's suggestion that the horizontal component of the normal force on the tool should balance the horizontal component of the tangential force. If this connection is fulfilled Mallock argues that the tool would show no tendency either to dig into the stock or retreat away from it. The authors found that with the exception of copper this condition could not be fulfilled without reducing the cutting angle to a value which led either to instability in the depth of the cut or to the immediate blunting of the tool. At angles above this value the friction is more than sufficient to secure the stability of the tool.

Finally, the authors investigated the effect of variations in the cutting speed upon the magnitude of the cutting forces. Using a tool of 65 deg. cutting angle, the horizontal and vertical forces were observed at cutting speeds ranging up to 80ft. or 120ft. per minute. The cutting resistance in the case of two of the materials was found to exhibit a definite minimum value at a speed of about 20ft. per minute. In the case of the other materials the indications of a minimum value were faint.

FLOW AND RUPTURE DURING CUTTING.

In the experiments described in Dr. Rosenhain and and Mr. Sturney's paper the main object was to study the deformation and flow of metal under the action of a simple cutting tool, and to observe the manner of separation by which the chip is formed. The stock operated upon consisted of mild steel normalised, and a 60/40 cast brass. The stock was prepared in the form of a bar 2.8in. in diameter, on which a number of fins, 0.1in. thick and 0.3in. deep, were turned at a distance of 0.2in. apart. The tools used were ¼in. carbon steel parting tools all treated similarly, and varied in form only as regards the top rake and the front clearance angle. No lubricant was employed. The stock was rotated so as to give a constant linear speed of about 50in. per minute. The experimental method consisted of driving the tool into the edge of

one of the fins to a set depth as indicated by the micrometer feed, and then stopping the rotation suddenly just before the stock had made one complete turn. The fin was then sawn as a disc from the stock, and the segment containing the partially formed chip marking the point at which the rotation was stopped was removed from the disc. This segment, after being coated with copper to protect the edges, was

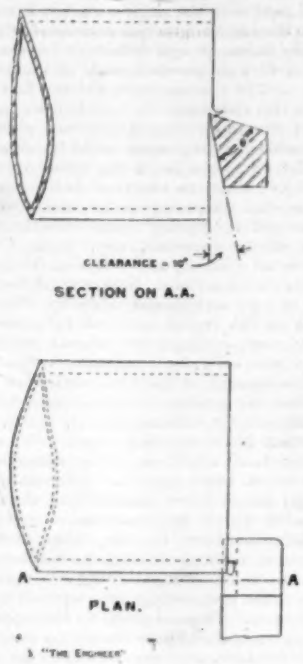

FIG. 1

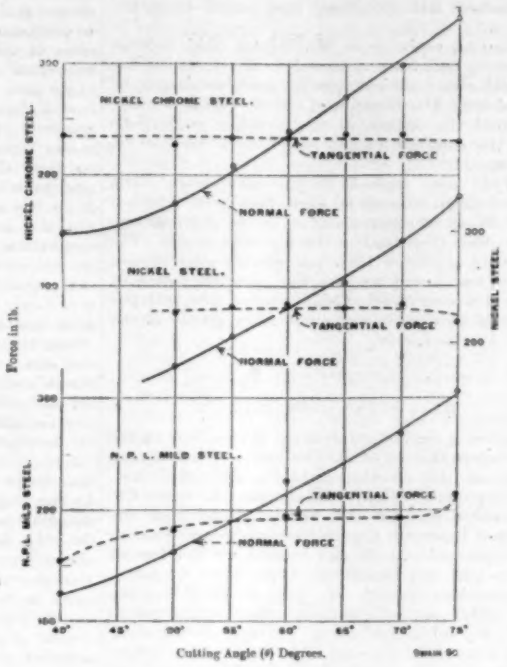

FIG. 2

sectioned parallel with the sides of the disc, polished and etched and examined microscopically.

In addition to varying the tool angles the depth of cut was varied. In general three types of chip were observed, the tear, the shear and the flow type. The tear type of chip is illustrated in Fig. 4, and is characterised by the fact that the chip separated from the stock by means of a tear running well ahead of the tool. This tear tends to run inwards, the material of the chip itself being crushed and sheared. As the cut progresses the depth of the crack increases, and the resistance to further tearing becomes greater until a point is reached at which the chip shears. This shearing may result in the complete severance of the chip or in a plastic displacement. In either case a fresh tear is started and again runs forward and inward in advance of the tool. If not severed the first time the chip finally shears off by a repetition of the plastic shearing and re-starting cycle. There is little or no real flow of the chip over the tool face. This type of chip is produced as a result of combining a relatively large depth of cut with a small top rake angle. Fig. 4 illustrates the tear in mild steel at a depth of cut of 0.01in.

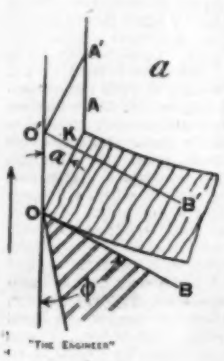

FIG. 3

An illustration of the second or shear type of chip in brass with a depth of cut of 0.025in. is given in Fig. 5. Tearing is very much less marked than in the first type, sliding along the plane A B predominating. This type of chip is produced by conditions intermediate between those producing the tear type and the flow type as, for example, by combining a small depth of cut with a small top rake angle. It is found that by reducing the depth of cut or increasing the top rake angle, the angle at which tearing occurs in the tear type of chip can be altered until the tear is nearly tangential to the cutting circle. Failure then occurs by shear at an angle of about 30 deg. with the line of motion of the tool. The effect of adding lead to brass or sulphide to steel for the purpose of making them "free cutting" is explained by these experiments. These impurities weaken the material transversely, particularly as regards resistance to shear, while leaving the tensile properties longitudinally practically unaffected. The result is that a shear type of chip results even although the conditions as to depth of cut and tool angles are such as would normally produce a flow type of chip.

The flow type of chip in brass at a depth of cut of 0.005in. is illustrated in Fig. 6. The metal leaves the stock as a ribbon more or less unbroken with an action analogous to that occurring during extrusion. Slipping is now predominant along the plane C D, which in brass was found to make an angle of about 60 deg. with the direction of motion of the tool nose relatively to the work. A clearly defined zone of great deformation occurs just in advance of the tool nose, but it is held that this zone is not produced as some have held it to be by particles scraped off the work and forming themselves into a solid mass between the work, the chip and the tool. The authors find that the deformed zone is continuous with the metal of the stock and chip. It was discovered that after annealing the microstructure of the deformed zone became normal and perfectly continuous with the microstructure of the metal on each side of it, a fact precluding the possibility of there being any mechanical separation however fine. As the top rake angle is increased the area of the deformed zone decreases until, with an angle of 30 deg., it completely disappears in brass. In the flow type of chip separation does not in general occur at the root but at some distance from it, and is caused by the bending forces applied to the chip when it curls over against the uncut surface of the stock.

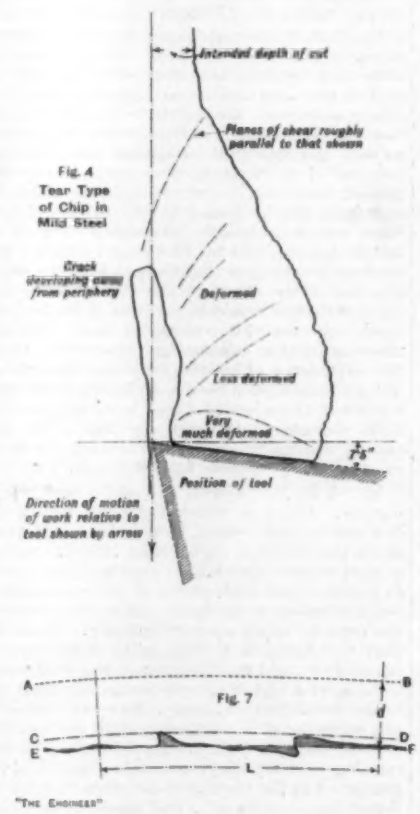
Intended depth of cut
Planes of shear roughly parallel to that shown
Crack developing away from periphery
Deformed
Less deformed
Very much deformed
Position of tool
Direction of motion of work relative to tool shown by arrow
"THE ENGINEER"

Fig. 4
Tear Type of Chip in Mild Steel

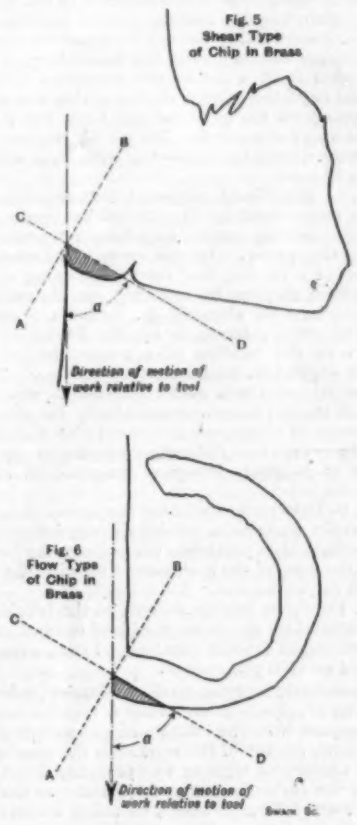

Fig. 5
Shear Type of Chip in Brass

Fig. 6
Flow Type of Chip in Brass

Fig. 7

FIGS. 4 TO 7

An important section of the experiments was devoted to an investigation of the state of the cut surface left when the cutting conditions were such as to produce chips of the tear type. The image of a known length of the disc edge was projected on a screen by means of an enlarging camera, and on the outline thus obtained the image of the uncut disc was superimposed as at A B—Fig. 7. The area between A B and the jagged outline was determined by planimeter, and from the figure thus obtained the average radius giving the arc E F was calculated. It was found that the intended depth of cut corresponded closely with the arc C D touching the crests of the irregularities. The average depth of cut was quite appreciably greater than the intended depth, and was found to be affected by the top rake angle of the tool. Thus in mild steel with an intended depth of cut of 0.01in. a top rake angle of 0 deg. gave an average actual depth of cut of 0.02in., while with a top rake angle of 20 deg. the average and the intended were practically identical. As a measure of the roughness of the cut surface the areas of the irregularities above and below the average arc—shown shaded in Fig. 7—were measured per unit of length. The irregularity curve was found closely to repeat the form of the average depth curve.

Sir John Dewrance, in moving a vote of thanks to the authors of the papers, intimated that other reports submitted to the Cutting Tools Research Committee were nearly ready for publication. From the technical point of view he recalled some experiments which he himself had conducted. From them, he said, he had definitely reached the conclusion that the actual edge of a tool did not do any cutting even with a very light cut, the cutting being done by the metal piled up on the nose of the tool.

Mr. William Taylor remarked that hitherto research on cutting tools had been almost wholly concerned with heavy cuts and on the endurance of the tools. But as accuracy and fine finish were often of importance in practical engineering, the Committee desired to learn more about fine cuts and therefore encouraged Dr. Stanton, Dr. Rosenhain and their assistants to prosecute the work dealt with in the two papers submitted that evening. There were many other aspects still to be investigated. For example, the tools so far used were not of a practical form and the influence of this departure would have to be investigated. Dr. Stanton had been asked to investigate the friction effect. In this connection it was worthy of note that in cutting glass plastic movement was impossible. The same remark was true of very hard steel. The sparks produced in grinding showed that the metal was being fused and wiped off. How far this effect persisted at ordinary temperatures was not yet known. A definition was required with regard to the form cutting angle. Dr. Stanton spoke of the solid angle of the tool as the cutting angle, while Dr. Rosenhain referred to the top rake angle as the cutting angle. [Dr. Rosenhain expressed his dissent.] In his, Mr. Taylor's, opinion the cutting angle included both these angles with an allowance for the rate at which the tool was fed forward. He disagreed with Dr. Rosenhain and Sir John Dewrance's contention that under certain circumstances the edge of the tool did not perform the actual cutting operation. If the edge

did not cut, why did it ever become blunt? When a screw thread was being cut with a tap it was exceptional to get a thread section identical with the section of the tool. The groove was either fat or thin and but rarely a counterpart of the tool form. Again, when a hole had been reamed a wrench was commonly required to extract the reamer, except in the case of cast iron and other highly crystalline metals. These facts seemed to him incompatible with the supposition that the actual cutting was performed by the deformed metal which became crowded upon the nose of the tool. If such were the case the cut or hole would be larger than the tool and not smaller, as was the case. Turning to Dr. Stanton's paper, he asked whether the experiments therein detailed covered the range of the three chip forms revealed in Dr. Rosenhain's contribution. If so, was any sign of change noticed in the forces measured which could be identified with a change in the chip form or was the change gradual and hidden?

Professor W. E. Dalby supported the view that the wedge of material in front of the tool did the actual cutting. That fact, he said, had been demonstrated by his own experiments.

Mr. P. V. Vernon remarked that the term "cutting angle" meant nothing at all to him. It was the top rake and the clearance angle that were all important. The top rake was of chief practical importance, because it could be taken that the clearance angle was constant at 5 deg. to 7 deg. The clearance angles used by the authors were not practical. Dr. Stanton adopted the value 10 deg., while in Dr. Rosenhain's tools it was as high as 20 deg. With these excessive clearances the tools could not be expected to stand up to their duty. He thought it would be useful if the authors would state how many and which of their conclusions were novel, and also if Dr. Stanton would give a comparison between the figures he obtained and those recorded by Nicholson. It would also be interesting to learn how Dr. Rosenhain's results for light cuts and low speeds compared with those given by heavy cuts at high speeds. The information given in Dr. Rosenhain's paper showed what a brutal process the cutting of steel really was. In removing metal from the stock the tool might tear the material or burst it, do everything in fact except cut it. Regarding the difference of opinion over the action of the cutting edge, he remarked that in making screw gauges it was possible to take a cut 2/10,000ths of an inch deep. If, then, the cutting edge of the tool did not do the work it must approach very nearly to doing so, for very little room was left for anything else to perform the operation.

Mr. H. N. Gresley having disposed of a problem in the dynamics of baby carriages propounded by Mr. Vernon, repeated previous requests to Dr. Rosenhain to explain why the cutting edges of tools became rounded and worn if they did not do the actual cutting. Dr. Rosenhain had said that the wedge formed part of the metal itself and was not separated from it. In turning hard tire steel a similar wedge was sometimes formed on the point of the tool, but it was separated from the stock. He would suggest that experiments should be conducted with hard steel as well as mild steel.

Mr. R. C. Macdonald suggested that the excessive clearance angles used by Dr. Rosenhain might have caused the tearing action to which reference was made in the paper. In his own experience the chattering of a parting tool used for planing a deep slot had been stopped by reducing the clearance on the tool to zero for about $^1/_{16}$in. behind the cutting edge. The effect referred to by Mr. Taylor in connection with the binding of a reamer in its hole might, he suggested, be due to temperature.

Colonel Kitson Clark asked whether it would be possible to study photomicrographically the chip left by the action of a hammer and chisel with the object of getting over the difficulty introduced by the necessity of suddenly stopping the rotation of the work in the lathe.

Mr. E. R. Dolby asked whether the action of cutting metal was not the same as driving a wedge into timber, and whether the particles composing the wedge stuck to the nose of the tool, passed on with the chip, or fell off as powder?

Mr. F. Robinson having referred to the lubricating effect produced by the presence of lead in brass, asked Dr. Rosenhain to explain why he used such a low cutting speed as 13ft. per minute.

Dr. Rosenhain, replying to the discussion, said that Mr. Taylor's argument involving a reamer was not a fair comparison. The binding action was produced by the elastic stretch of the work. In the case of cast iron the absence of binding was probably due to the fact that the carbon acted as a lubricant to the tool. Dealing with the wedge effect, he called attention to the fact that the photomicrographs in the paper were very much enlarged. He was not at all afraid even of Mr. Vernon's two ten-thousandths of an inch. The cutting edge of the tool was very close to the cutting line, so that a very minute breakage at the point of the tool would affect the conditions. When such breakage occurred the action completely changed and wear took place. It was to be remembered that all the photographs and data in the paper referred to tools in a fresh and sharp state. Replying to Mr. Gresley, he said that the metal which adhered to the tool was only a part of the whole deformed mass. It appeared to be clear that the particles of the deformed zone remained constant in position relatively to the point of the tool. He agreed with Mr. Vernon's characterisation of cutting action as brutal. He was not convinced that it was possible to cut any material without bruising, splitting and tearing it. Even the edge of a razor was of immense dimensions relatively to interatomic distances. The action of shaving was to be likened to the passage through a forest, not of a gigantic sharp axe or scythe, but of a war-time tank, which crushed and splintered and broke down the trees.

Dr. Stanton, replying to Mr. Taylor, said that no discontinuity had been detected in the force on the tool at different cutting speeds, such as might be associated with Dr. Rosenhain's three forms of chip. As regarded the definition of "cutting angle," he followed the example of the Manchester Association of Engineers.

Mr. Hyde also replied to the discussion. The alleged excessive clearance angle had been adopted with the object of eliminating as far as possible any influence other than that of the top rake angle. The slow cutting speed of 13ft. per minute was chosen because it was found to give the same character of results as a cutting speed of higher value, say, 80ft. per minute, and because it was much more gentle to the tool and dynamometer.

WIRE ROPES RESEARCH.

THERE was a capital attendance of members of the North-Western Branch of the Institution of Mechanical Engineers at the meeting held on the 22nd inst. at the Engineers' Club, Manchester, to hear Dr. W. A. Scoble present the Second Report of the Wire Ropes Research Committee, and there was an excellent discussion. It was opened by Mr. Daniel Adamson, who expressed the hope that criticisms and suggestions would be put forward by the meeting which would encourage the Committee to proceed. He submitted some figures of actual work done by wire ropes on cranes in engineering shops. In one shop, he said, there were two 30-ton and one 10-ton cranes, which made 15,000 lifts per annum each, the average life of the ropes being twenty years, which was equivalent to 300,000 lifts. The barrels and sheaves of these cranes varied from 22 diameters of rope up to 25 and 28, the sheaves being larger than the barrels. The cranes were considered to be lightly loaded. He also cited the case of two 5-ton cranes which made 30,000 lifts per annum each, with an average load of 2 tons. The ropes in these cases only lasted eighteen months, or 45,000 lifts. These figures showed that the lighter cranes were generally much more heavily loaded than the heavier cranes. The sheaves were 21 to 27 diameters of the rope.

Mr. R. B. Murray spoke on lift ropes, of which he had much experience. He said there was an essential difference between the method of loading the rope in the test and the actual loading in lift practice, where a friction sheave drive was employed. The test pieces, although stressed, were only called upon to turn the rope pulleys against friction, whereas in the case of the V drive, the tractive force was transmitted from the motor through the reduction gear and from the V sheave to the rope. This tractive force was considerable, averaging in a 10 cwt. lift 560 lb. transmitted by frictional contact. It tended to cause creeping or slight slipping of the ropes in the grooves of the sheave, thus the abrasive wear was heavier than it would in the case of the lengths under tests. It was interesting to note the reporter's observation that lubrication reduced the life of a rope. The experience of his company was that the majority of rope breakages were due to internal corrosion. The surface of the wires of a rope were large as compared with the area. If corrosion began, the rope was rapidly weakened; hence the necessity for a lubricant or some other medium to preserve it.

Mr. C. E. Hill wished the report had gone a little further. The wire which had been used in the ropes did not exceed .036in. in diameter, and the carbon of the steel was not higher than .136in. In examining a good many ropes which had failed, he had found, in general, that with about .4 per cent. carbon there was hardening of the surface of the wire which caused the rope to break up very quickly. In actual practice, the ropes most frequently used were 2in. circumference, and the diameter of the wire necessitated the use of a higher carbon percentage than that used in Dr. Scoble's experiments. He would like to mention one other point in connection with the wearing of the rope around the pulley. In ordinary practice, when running over a pulley, a certain amount of heat was generated at the surface of the wire forming the rope. When high-tensile wire was raised to a temperature of about 200 deg. Cent., the elastic limit was raised, and the tensile strength was raised, but the bending value was decreased in a remarkable way. That characteristic would explain the breaking due to the bend of the wires of the rope round pulleys.

Mr. E. A. Atkins said that the factors which governed the life of wire ropes were very many. They started with the steel ingot. He ventured to say that if Dr. Scoble had gone to two or three wire manufacturers for identically the same wire, and had made it up into ropes, his results would have differed, on account of the varying treatment of the wire. There were many other factors that governed the life of a rope. The most important factor of all was treatment in service.

Mr. Geoffrey K. Rylands, who regretted his inability to attend the meeting, sent in a written communication, in which he said it was noticeable in the report that a good deal more attention was paid to the construction of the rope or strand than to the quality of the wire. There was no doubt that comparisons could be made between different constructions of strand and rope with the same wire, but it was unwise to compare the same constructions made from different sizes of wire unless it was definitely known that the two sizes of wire in question were of identically the same steel and in the same condition. His firm had found that the only way by which reasonable comparisons of the properties of different sizes of wire under repeated bending tests could be obtained was to draw the two sizes from the same 5 gauge rod, and to subject them to identical reductions in area from the second tempering point, and also to carry out the second tempering under exactly the same conditions of temperature, &c., and, if possible, at the same time or, at any rate, on the same day. As regards comparisons between different constructions of rope and strand, although the comparisons made in the report were of extreme interest, when they were confined to strands involving the one size of wire only, he personally believed that a considerable amount of research work was necessary on the particular quality of wire it was desirable to use for different constructions, and, again, it might be found that for compound constructions, such as 12 by 6 by 1, it would be more advantageous to use inner wires having rather different properties to the outer wires, for it was evident that the conditions under which the inner wires worked were entirely different from the condition under which the outer wires worked. Generally speaking, he felt that there was no knowledge resting on a real scientific basis as to what properties were required in wire for roping purposes. There seemed to be a general concensus of opinion that the wire should stand a large number of torsions, and many people, he was sure, really believed that the greater the number of torsions which the wire would stand the better its quality. It was difficult to know how that idea had arisen, for evidently the torsional stresses of a wire in a rope were very small, and certainly did not justify the imposition of such an elaborate test. High torsions might be obtained by the wire manufacturer at the expense of other properties which would be of far more value in rope wire.

Dr. Scoble, in his reply, said that Dr. Morley was associated with him in the days when he started with wire ropes, and the thing that had struck them was that nobody seemed to be quite sure what the torsion test was for. It was a common thing for people to say that the torsion test indicated the ductility of the wire. As a matter of fact, the ductility of the wire had nothing to do with it.

LARGE SINGLE-PHASE LOCOMOTIVES.

THE Loetschberg Railway Company has just placed an order with the Société Anonyme des Ateliers de Sécheron, of Geneva, for two large single-phase locomotives. Each of these engines is to be rated at 4200 horse-power on the one-hour basis, and they will be the largest locomotives equipped with single-phase motors. Considerably more powerful engines are, of course, being built in America, but those locomotives will be equipped with phase converters for charging the single-phase current collected from the overhead wire into polyphase current. The new Swiss locomotives are to be used for goods and passenger traffic, and will be employed more particularly on the mountainous part of the railway, between Frutigen and Kandersteg. The engines are to be designed for a normal speed of 50 kilom. per hour, and a maximum speed of 75 kilom. per hour, the load on the driving axles being 19 tons. Trains weighing 560 tons, excluding the weight of the locomotive, will be hauled on a gradient of 2.7 per cent. at a speed of 50 kilom. per hour. The locomotives will be of the 2-6-6-2 type with six twin motors, each capable of developing 700 horse-power for one hour, thus giving a total output of 4200 horse-power. Power will be transmitted to the driving wheels by means of an individual drive of the Sécheron type. Oil immersed transformers are to be used for reducing the line pressure and for supplying a variable voltage to the driving motors, which will be controlled by means of electro-pneumatic contactors, the arrangement being the same as that adopted on the single-phase locomotives built at the Sécheron works for the Swiss Federal Railways—see THE ENGINEER, March 21st, 1924.

The principal dimensions, weights, and capacities of these new engines are as follows:—

Length over buffers	20.200 m.
Diameter of driving wheels	1.350 m.
Number of twin motors	Six
One hour rating measured at the rim, at a speed of 50 kilom. per hour	4200 horse-power
Tractive effort measured at the wheel rim, one hour rating	22.6 tons
At starting	34 tons
Total weight of the mechanical parts	67 tons
Weight of electrical parts, including individual axle drive	68.5 tons
Total weight in service	135.5 tons
Adhesive weight	114 tons
Maximum speed	75 kilom. per hour
Line voltage	15,000 volts
Frequency	16⅔ cycles per second

Industrial Standardisation.

THE majority of people probably are already converted to the idea of industrial standardisation. Objections are usually to the effect that standardisation interferes with invention and design, and especially with individuality, that it tends to produce crystallisation and eventually to stultify general progress. Such objections are very real ones and can only be dealt with satisfactorily by proper safeguards very strictly applied. A certain amount of opposition to the work of standardisation is to be expected; in these days, however, it is somewhat expensive to be too individually inclined. If an engineer, for instance, wishes to insist upon his individuality he can always be accommodated—at a price; but the ordinary average man prefers to use materials and apparatus produced in accordance with national specifications in order to secure the resulting saving in cost. On the other hand, there is a certain number of fanatics who would standardise everything, but I think it is generally accepted that extremists in any walk of life have to be firmly suppressed.

The term "Standardisation" is an unfortunate one. It seems at once to give the idea of crystallisation, of the setting up of an unalterable standard, and I do not think too much stress can be laid on the fact that industrial standardisation is nothing of the sort. Indeed, in the work of the British organisation there are very few actual standards throughout the specifications already issued, which now number well over 200, exclusive of those for aircraft purposes issued for our Air Ministry. Fundamental standards of mass, length and time, as well as standards for electrical measurements, in most countries are dealt with by the National Physical Laboratories, whereas the national specifications prepared by our organisation are rather in the nature of a handy tool to be used with contracts for the purchase of materials and apparatus on the most economical lines.

The British standard specifications are arrived at by unifying the needs of industry and recommending what is best in present practice and what can be adopted by industry with the least possible disturbance. In its broadest sense it means national simplification, the reduction of the number of types and patterns used for one and the same article.

The main object of industrial standardisation or unification is the saving of waste through the simplification of manufacture tending towards national economy. In Great Britain there has been no attempt to force standardisation nor to set up an ideal straight away, as it was felt in most cases that would be too costly for industry to adopt. On the other hand, one has to acknowledge that many industries are still bound by tradition and drift along with an enormous diversity of spare parts, making no attempt to simplify or standardise. This means a vast amount of stock, a slow turnover and high cost of production.

The setting up of national specifications for quality and performance, whereby proper comparisons can be made, and the unification of tests and dimensions of component parts where interchangeability is necessary, are some of the advantages to be gained. Rapid and economical production may be claimed as one of the leading benefits, for it assists not only the manufacturer but also the consumer in the rapidity with which his orders can be fulfilled from stock; there is also the ready and quick replacement of damaged and worn parts and not infrequently a reduction in the selling price.

Whilst the attempt to standardise whole machines is to be deprecated, the standardisation of component parts with a view of obtaining interchangeability is of immense value not only to the purchaser in quick delivery but also to the manufacturer. The proper safeguards are periodical review and revision of the national specifications; the adoption, therefore, of these uniform specifications goes a long way towards minimising the cost of tendering to the manufacturers, and brings into commercial transactions greater confidence and simplicity as well as protection to both user and producer against unfair competition.

It would be a mistake to think, however, that this national work is confined solely to the setting up of these specifications, highly important as they are to the progress of industry. The fact of bringing people together to discuss the best methods of unifying and simplifying their requirements, in which they all have a common interest, is of equal if not more importance, as it quickly establishes points of contact, enabling them to arrive at an understanding amongst themselves impossible in any other way. Industrial standardisation, after all, is very largely concerned with the human factor, and in dealing with this side of the problem the establishment of friendly relations is of paramount importance. For the manufacturer it is a business proposition from which an adequate return should be expected. From the people's point of view it is a process of simplification, a saving of time and material, a progressive step in the industrial sphere, lightening the general burden and tending to raise the human level. It is, in fact, service to the community.

A very important point in this national simplification is that the specification should have an economical basis. If this is kept well in the forefront the result will be the production of national specifications which, though perhaps not entirely ideal, will represent the best which can be advantageously attained at the moment, it always being understood that improvements will come about through the process of time. National specifications drawn up in this manner are likely to be adopted rapidly by the community as a whole, for instead of being costly to introduce they will actually produce all-round economies.

Whilst every care must be exercised to prevent crystallisation or lagging behind industry, the national specifications should have a certain measure of permanency if they are to be received with confidence in industry, and the specifications should not be changed too often unless such changes are distinctly in the direction of improvements.

Such standardisation is very far from fossilisation or stultification; it invites improvements and progress. The specifications drawn up on this basis are arrived at through the elimination of the unnecessary and the recognition that the recommendations are not unalterable, but subject to review whenever industry itself feels it economically desirable or necessary to do so.

Finally, it is our experience that to be of lasting benefit the proposals for standardisation or simplification should emanate from industry itself. The manufacturers are in daily contact with the machinery or apparatus under consideration and are in the best position, by co-operation among themselves, to put forward constructive proposals for simplification which can be adopted by the committee. Criticism of these proposals can be supplied by the scientific and technical experts of the users. These are the principles upon which the British standard specifications are drawn up, and it is due, I think, to these principles having become so well established that these specifications are becoming so widely recognised and used throughout our country.

National standardisation is really a science all of its own, and it is only gradually that the underlying principles have evolved themselves and its great economic value become recognised.

The work of the British Engineering Standards Association covers the engineering and allied industries and embraces quality of materials, dimensional standardisation and the unification of tests. It is divided into eleven sections, viz., Aircraft, Automobile, Chemical Engineering, Civil Engineering, Colliery Requisites, Electrical, Mechanical, Metallurgical, Petroleum Products, Ships' Materials and Fittings, and Transport.

The Association does not initiate standardisation but waits for pressure from outside before undertaking such work. In fact, it is only on the request of a representative technical or trade organisation, or a Government department, that the main committe acts, and even then before appointing a committee to study any subject it authorises the holding of a representative conference of all concerned, in order to be certain that there is a concensus of opinion favourable to such work being carried out and that it is to fulfil a recognised want. The matter is fully ventilated at such conference, and it is on its report, if it be favourable, that the main committee takes definite action by the appointment of what is called a sectional or departmental committee. The main committee reserves to itself the right to nominate the chairman, but after that the sectional committee has to work out its own salvation. The sectional committees in some cases represent a whole industry, such as does the sectional electrical committee; at other times it is representative of materials, as in the case of the sectional committee on non-ferrous materials. The B.E.S.A. does not exercise coercion in any way whatever; it has no other authority than that of engineering public opinion. It is not a profit-making concern, it has nothing to get but all to give for the benefit of British industry.

You will have appreciated from what I have said some of the difficulties we have to contend with as well as some of the success which has been achieved. I feel that this success is largely due to the fact that so much care is taken not to put forward any national specifications which have not received the full backing of industry prior to their issue. To do this means endless conference and consultation, but it pays in the long run. To go from that to international standardisation obviously means a great increase in difficulties. You have at once the difference in units, difference in language, as well as racial characteristics. However, whilst international co-operation is still immensely difficult, some progress, at any rate, is being made towards bringing the national standardising bodies together through the efforts of the unofficial conference of secretaries. This is a permanent body authorised by the main committees of the different national standardising bodies. It has infrequent meetings, but the members are constantly in direct communication with each other through the secretary of the Swiss committee, who acts as a centre of correspondence. A good deal of useful simplification of methods and procedure has already been accomplished; periodical information in regard to the work in the respective countries is circulated, and copies of the various national specifications are automatically distributed, so that each organisation has the standards of all the others. My organisation has decided on principle that each of its B.S. specifications shall have metric equivalents placed alongside the British dimensions in order to meet, as far as possible, the requirements of engineers and purchasers in those countries where the metric system is the prevailing one.

* From an address given by Mr. C. le Maistre, Secretary, B.E.S.A., in Prague and Brno, at the invitation of the Czecho-Slovakian Engineering Standards Committee, December, 1924.

Saint Paul's Cathedral: Its Structure, Defects and Repair.

By WILLIAM HARVEY.

SAINT PAUL'S CATHEDRAL, now classed as a "dangerous structure," presents some problems of extraordinary interest in connection with its great breadth, height and weight compared with the restricted bulk and the limited strength of the material employed in its construction.

The second interim report of the Commission appointed in 1921 to advise upon the best methods of repair hardly does justice to these considerations of constructional science, to historical interests, or to the building itself. A proposal to grout the interior rubble core of the eight main piers of the dome with cement under pressure, and to replace the damaged facing stones, cannot be considered satisfactory when the same report contains the admission that larger works, the rebuilding of the piers, and perhaps of the dome, will be required in future.

These pronouncements and the dangerous structure notice which followed closely upon their publication, raise the question whether some adequate course of repair is not possible which would conserve the dome at the same time that it puts an end to the continual disquiet concerning the safety of the building. Though recommended in the Commission's report, patching will only prolong the agony, and demolition of the domed central portion of the church would deprive us of some priceless historical evidences of Wren's constructional genius.

An imitation of Wren's dome would not possess a tithe of the interest of the genuine building that was erected to his design under his personal supervision, and that bears evidence of the development of his mental outlook. Repairs of a comprehensive kind are possible to modern constructional science, but they must be directed towards the complete conservation of the veritable structure left to us by Wren. The invention of an adequate scheme that will reconcile structural with historical and artistic considerations, must be based not only upon a thorough knowledge of the present state of the building, but also upon the principles and practices of the best works of conservation that have been carried out in recent times.

It seems incredible that the systematic reinforcement of the walls of Rievaulx Abbey or the recoring of the tower piers at Jedburgh should be altogether ignored in the repair of St. Paul's Cathedral. The proposal to limit repair work to grouting and patching is preposterous under the circumstances, for where the dimensions of the building are so vast and the loads so concentrated that the tenacity of the cement or the strength of the stone is called in question, deficiences in structural equipoise cannot be made good by the insertion of a few facing stones and some cement grout.

By such measures the stresses are not diminished, and may even be considerably increased, and it is only a question of time before the symptoms of decay reveal themselves anew.

That this would be the case in St. Paul's Cathedral can hardly be doubted. Plentiful evidence exists of the large settlements in the substructures during and immediately after the construction of the building, and the historical patchings that were applied then have not prevented the further decay and the opening up of new cracks. Experience of the behaviour of ruined masonry buildings with heavy excentric loads confirms these recent movements in the structure of the Cathedral, and indicates their origin in excessive excentric loading, the imperfect transmission and diffusion of pressures and a partial failure of the buttressing system.

Whether the present building be patched or rebuilt, fractures and dislocations of the masonry will take place from time to time unless the fundamental defects in its statical equipoise are corrected, and this may be done by scientific adaptation of the existing building at a far less cost than would be required in any scheme of demolition and re-erection.

But, in the first place, a thorough examination of the building and of its tendencies to fall apart in detail would have to be made for the purpose of discovering its deficiencies and learning how best to make them sources of strength instead of weakness, by the provision of a minimum of new material. Something more than a survey of the present state and defects would be demanded. The Commission has spent three and a-half years in investigation, and after numberless observations of movements and fractures, recommends patching and grouting of the main piers—to the dissatisfaction of the City surveyor! Some guiding idea is obviously required.

The history of the Cathedral cannot be ignored in any examination into its construction. St. Paul's was not designed and built as the culminating work of a long series of buildings, each one finer, sounder

and larger than the last, but as the result of the imaginative efforts of a young Doctor of Medicine and Science, whose inventive turn of mind and experimental studies in astronomy, microscopy, vivisection and mathematical theory had impressed his powerful friends at court with a sense of his exceptional ability. To all these studies, Wren added classical research into the architecture of the Romans and the practice of architecture in accordance with his researches as far as was humanly possible. The architecture of the Roman Renaissance was a somewhat exacting art, and though Wren protested against rules of too hard and fast a description, his work suffered in its constructional side by too close adherence to them.

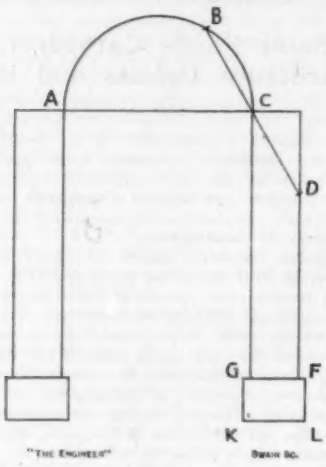

FIG. 1

Wren's illustration of a former erroneous method of computing the abutment necessary for a round arch. He proposes to substitute a method in which the centres of gravity of the parts are determined.

The defects which are receiving the attention of the Commission and the public at the present time are not all to be laid to the discredit of the artistic style adopted by the architect. Some of them may be charged to the ordinary building methods of his day, and others to the fact that he was working in the light of his own imagination and study, and without the example of kindred buildings to guide him.

The tradition of building construction had reached a low ebb when Wren produced his design for the Cathedral and obtained from Charles II. the Royal warrant for its erection on May 14th, 1675. The construction of large vaulted buildings had become rare in England. The sumptuous Tudor palaces of Hampton Court and Nonesuch were famous for their rich decoration in cast lead, carving, painting and gilding, and not for the mighty span or height of any individual chamber.

As a mathematician Wren was capable of computing accurately the effects of pressures and resistances up to a certain point, and some of his constructional expedients are marvels of efficiency, but it was impossible that his attention should be directed in time to every necessary problem, and in some cases the decadent tradition of his masons was allowed to settle matters for him. This was the case in respect to the composite construction of the piers and walls of the church, with facings of ashlar and infillings of lime and rubble concrete; the plentiful supply of old stone from the demolished old St. Paul's doubtless formed an additional inducement to adopt this practice.

As the work progressed and the architect became more and more master of the constructional arts, he seems to have realised the necessity of insisting upon better ways of his own devising, but in its early stages it is probable that he was less inclined to doubt the efficacy of the normal methods of his time and those of the Gothic builders with whose works he was well acquainted.

It must be remembered, too, that outside a circle of a few exceptionally brilliant men, theoretical or applied science was practically non-existent in England, and mentally alert and untiring as Wren must have been, it was impossible for him to recognise at a glance just when it was vitally important for him to improve upon or reverse some accepted time-honoured tradition. The following extract from his writings indicates how one great structural feature, the abutment of the arch, was "calculated" before the time of Wren, and also shows his attitude of mind towards scientific economy of building. In both

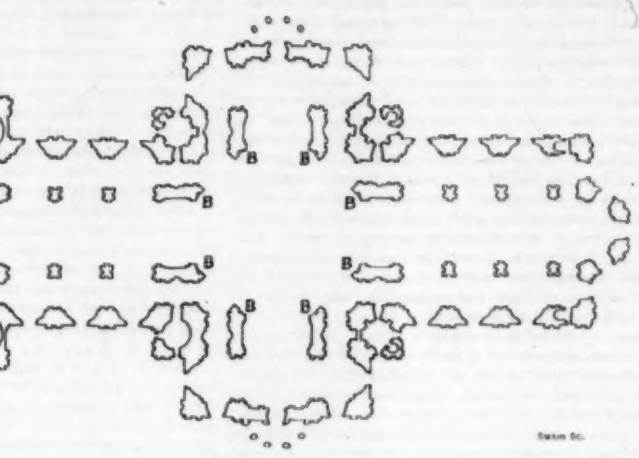

FIG. 2

Maximum loads applied to piers at B on one corner of each. Practically all the defects in the central part of the building may be accounted for by this excessive and eccentric loading. Wind pressures, vibration and subsidence probably contribute to movements and fractures primarily caused by errors of load distribution, and the transmission of thrusts.

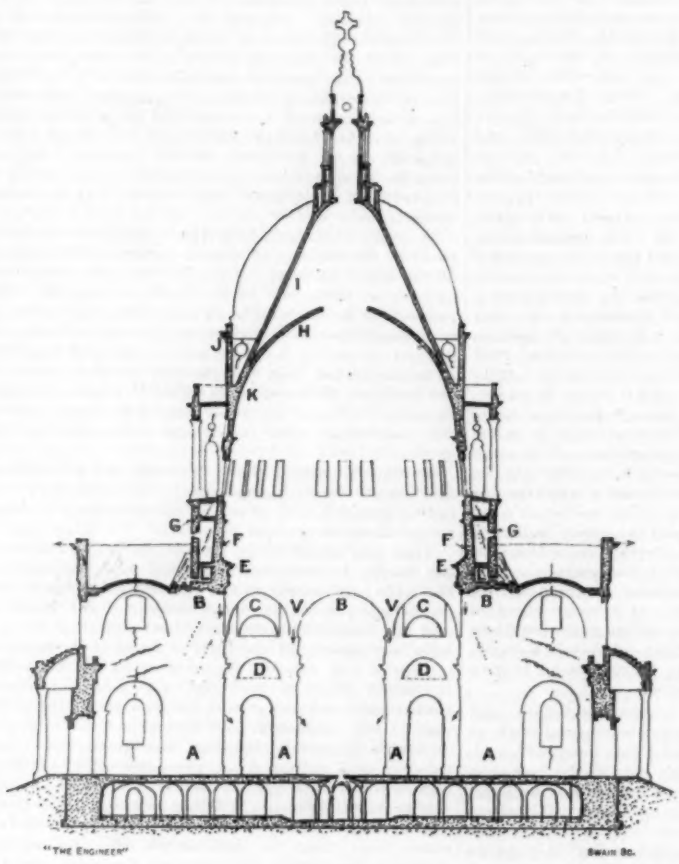

FIG. 3

Cross-section of St. Paul's Cathedral through Transepts. Present state with defects. A A, eight principal piers. B B, main arches applying concentrated pressures by means of their common imposts upon restricted portions only of the piers A. C D, upper and lower alcoves with round-headed arches incapable of spreading the weight of the central mass to the bastions in an efficient manner. E, whispering gallery, surrounded by thirty-two cells and thirty-two defective diaphragm walls and buttresses. F, heavy inner drum. G, light outer drum. H, inner dome. I, cone. J, vertical upper drum. K, position of iron chain. L, stone-built cells.

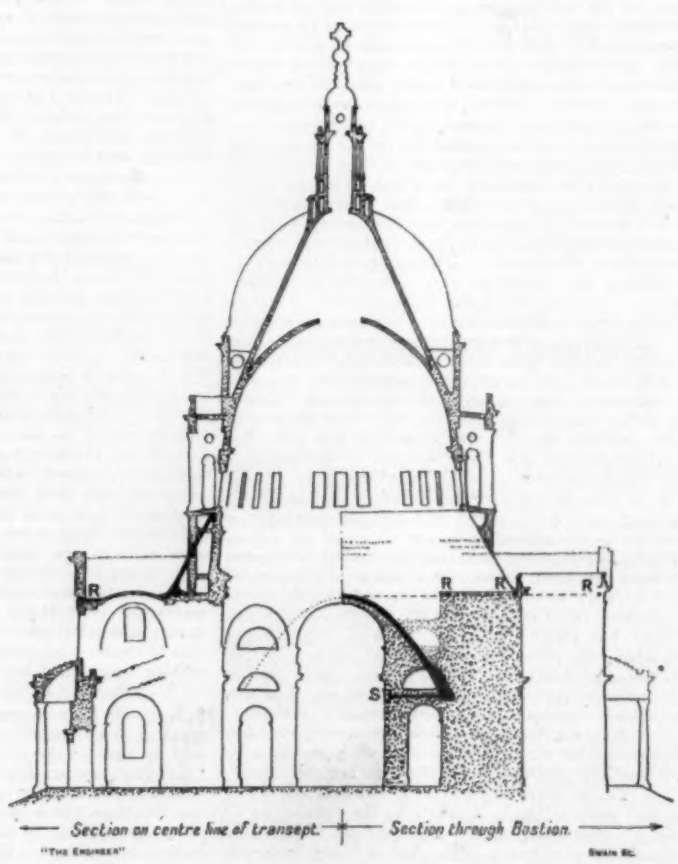

FIG. 4

Sections showing a possible scheme of repair in which the thirty-two defective buttresses would be aided by a new cone of reinforced concrete designed to distribute some part of the weight of the drums upon the unloaded back portions of the eight main piers, the bastions and the surrounding walls of the building. R, reinforcement buried in wall tops to prevent further movement in the building. S, anchor bars and plates to distribute thrust of foot of cone and correct existing thrust of aisle vault.

these respects it throws light upon the state of the work in the Cathedral.

"It seems very unaccountable that the generality of our late architects dwell so much upon this ornamental and so slightly pass over the geometrical, which is the most essential Part of Architecture. For instance, can an Arch stand without Butment sufficient? If the Butment be more than enough, 'tis an idle expense of materials; if too little, it will fall; and so for any vaulting. And yet no Author hath given a true and universal Rule for this, nor hath considered all the various Forms of Arches. The Rule given by the Authors for the Butment of Arches, is this: (see Fig. 1). Let A B C be the Arch, of which B is a third Part; extend the Line B C, make C D equal to C B, and draw the Perpendicular D F, this determines the Butment G F (as they say) but wherefore? For add to the Bottom, as K L, the Arch must then certainly press more upon the higher Part than the lower; or if some additional weight be added above the Arch, that must still press more than before this was added. So this Rule (if it were built upon any sure geometrical theorem, as it is not) is neither true nor universal; and what is true will be shown to be only determinable by the Doctrine of finding the Centers of Gravity in the Parts of the proposed Design."

The attempt to avoid "idle expense of materials" becomes apparent on examination of St. Paul's, and most emphatically so, when that building is compared with St. Peter's at Rome, where the piers supporting the dome are gigantic solid masses, which block up the aisles completely. Wren, on the contrary, set great store upon an uninterrupted vista down every avenue and upon the omission of any projecting masonry that might narrow down the grand Central Nave. The eight main piers of the dome are, therefore, kept in line with the ordinary arcade piers of the Nave, and are only slightly thickened on the side next the aisle. In plan they are long and narrow—9ft. by 30ft.—but appear to be well buttressed by bastions at the four re-entrant corners of the building, where the transepts adjoin the Nave and Choir. These bastions only contain comparatively small chambers, such as vestries and staircases, and are surrounded with thick walls more massive than the main piers.

The plan is articulate in that almost every arch has a possible buttress mass in alignment with it; but the section of the building is not so competently designed in respect to arch thrusts as the plan seems to promise, and the vaults and arches have occasioned that weights like thrusts might be brought to their foundations in an orderly progression from light to strong—Fig. 9. The concession to the requirements of the Roman manner in the matter of round arches is regrettable in St. Paul's Cathedral, for, unlike the toy structure of Temple Bar, its size and weight generate pressures calculated to search out all the weak spots in the design.

Other deficiencies in buttressing occur in the transepts, the end walls of which have been pushed out and the arches and vaults distorted. In each transept large round-headed arches span the space between the

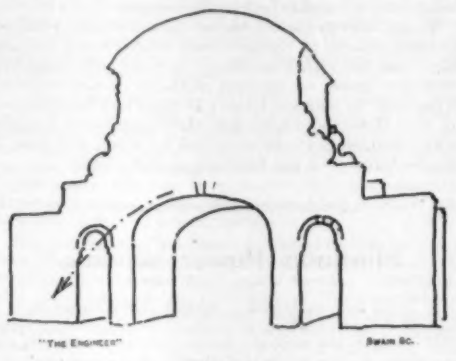

FIG. 9

Temple Bar, an ornamental gate-house designed by Sir Christopher Wren. It illustrates on a small scale a defect of abutment and thrust management, which also exists at the side of each great arch of the domed area of St. Paul's Cathedral. The line of thrust must traverse a round-headed arch before reaching its buttress.

outer front walls and the two main piers, and these arches carry a considerable load of clerestory wall. At a higher level the domical vaults of the transepts also press outwards upon the unbuttressed face walls, which are not substantial enough to control the thrusts by top weight as they are thinned down from the inside above the main interior cornice—Figs. 3 and 4. This leaves the outer face of the wall more heavily loaded than the inside, and therefore inclined to overturn outwards under its own excentric load whether pressed upon by arch thrusts or not.

In the absence of tabulated strengths of materials Wren had to use his judgment as best he might in reference to the bearing areas of piers and the weights they were to carry. Domed buildings like that which he was erecting were not available for comparison, and the proportion of areas to pressures in existing Gothic buildings did not necessarily apply to the altered style, the new disposition of masses and the immense scale of the new building. Many Gothic piers are subjected to excentric loading, to bending and even to torsion, and were expected to stand a certain amount of misapplied pressure in the ordinary course. The masonry of a Gothic building was practically known to possess a certain value in what would now be called cross stress. Gothic arches and vaults were almost invariably brought down upon outcorbelled imposts, the well-understood cantilever action of which was useful in combining the vertical weight of a pinnacle with the oblique thrust of the arch. In a few Gothic examples, this over-confidence in material has resulted in shearing of the stonework and collapse of the vault, but in the great majority of cases the pressures have been resisted satisfactorily to all appearance.

While Wren despised Gothic building, he absorbed unconsciously a confidence in the tenacity of stonework that would have astounded the Gothic master builders, and throughout the whole fabric of St. Paul's Wren's undue trust in the use of masonry under cross stress has induced defects and fracture in what might have been, from the disposition of its masses on plan, a thoroughly well-balanced building.

The excentric loading of the outer aisle walls and the face walls of the transepts has already been mentioned. This was a retrograde step as compared with the design of a Gothic buttress, which is loaded with its pinnacle in a manner calculated to improve the resultant line of arch thrust and reduce it to a direction as nearly vertical as may be at the nearest convenient point. Both in the small Temple Bar and the lower parts of the gigantic Cathedral Wren failed to show that he realised the importance of correcting the thrusts as early as possible. During the progress of the work he must have been acquiring experience, however, and the possible outward thrusts of the sloping drum and cone are top weighted with vertical drums of masonry which show on the section in very much the positions that a Gothic master would have chosen for them. The enormous weight of the sloping inner drum and the vertical outer drum are placed too near the centre of the building and the marked excentricity of appli-

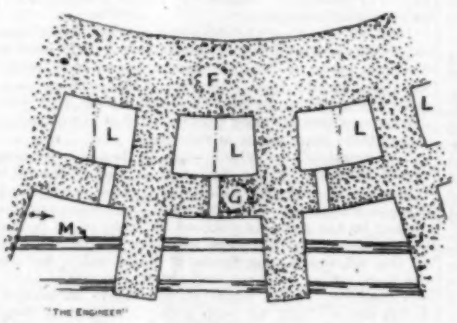

FIG. 5

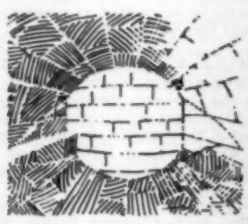

FIG. 6

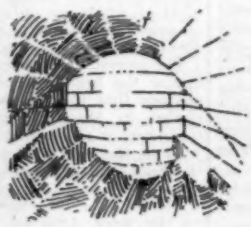

FIG. 7

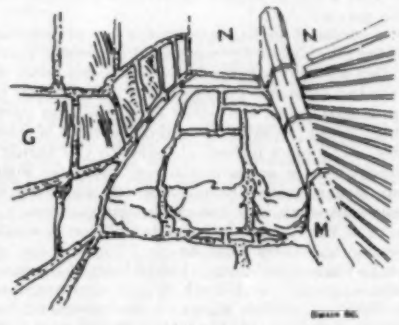

FIG. 8

FIG. 5.—*Part plan of inner and outer drums, with diaphragm walls separating cells* L L *and buttresses on the exterior of the outer drum.* M, *inverted arch rib over great arch. The arrow shows direction of view shown in Fig.* 8. FIG. 6.—*One of the thirty-two cells surrounding the drum at Whispering Gallery level. The inverted arch presses upon the crown of one of the great arches.* FIG. 7.—*Cell between inner and outer drums. The inverted rampant vault presses against the haunch of one of the great arches. Note its axis is parallel to that of the church. The axis of the ceiling and of the cell radiates towards the centre of the dome area.* FIG. 8.—*View over haunch of great arch. Outer drum* G *on left. Inverted rampant arch* M. *Lower parts of buttress* N N *in background.*

some outward movements in the exterior walls—Figs. 2 and 3. The use of Roman round-headed arches has something to do with this, and the great load of the high central part of the building would, of course, tax the stability of arches, whatsoever their shape, if mounted upon slender piers rising to a height of 65ft. from the ground. The pressures of the great arches under the drums find their way into the bastions and into the long blank walls built above the aisle walls upon the exterior of the building.

This is a masterly arrangement of material calculated to spread lateral thrusts over a large area of wall base and to oppose them by a heavy but diffused weight of counterfort. Unfortunately the connection between the buttress mass and the main pier is made by means of round-headed arches, which have become distorted with unequal settlement. Although somewhat crippled in line, the arches continue to do their work, though not so efficiently as would have been the case had half arches of flying buttress form been substituted for them. The round arches forbid any adequate diffusion of weight, and it seems that, although Wren designed his buttressing system with great skill, the idea of spreading the vertical component of the load did not occur to him—Figs. 3 and 4. The little building known as Temple Bar is an instance of Wren's playful treatment of arch pressures and buttresses, and is also an extreme instance of concentration of loads; but it must be remembered that Wren had not before him the example of the late M. Eiffel's great tower, and it was only late in life that he realised

The high blank upper parts of the aisle walls, which receive and diffuse the lateral pressures of the high vaults of Nave and Choir are built in a similar manner with the bulk of their weight on the outside. These walls, so usefully placed in regard to thrusts received upon their ends from the great arches of the central domed area, are thus imperfectly poised in regard to the thrusts of the aisle and Nave vaults, and tend by their excentrically applied weight to produce overturning moments in the same direction as the vault thrusts.

The pressures from the high vaults are conducted down to the aisle walls by means of flying buttresses of constructional shape; the fact that they are hidden behind the blank upper parts of the aisle walls in deep areas over the aisle roofs having permitted Wren, in this instance, to disregard the rules of true Roman architecture. The flying buttresses are practically invisible, even in views taken from the air, and Wren's writings leave no doubt that he was intensely anxious to avoid the accusation of any leaning towards Gothic style. But, much as he wished to avoid it, and greatly as he improved upon it, in some respects the old tradition persisted in spite of him.

A false confidence in the strength of masonry may easily be gained by the detailed examination of Gothic vaulted buildings, which are almost always skeletonised to a dangerous degree, and only endure with the aid of continual repairs, renewals and even more or less wholesale rebuilding.

cation of the load is the principal cause of the defects in the piers.

The weight of the drums and domes has been variously estimated at from 40,000 to 48,000 and even 64,000 tons, and even the lowest figure gives a high average value for the safe resistance of a rubble-filled fat-lime built ashlar-faced pier, supposing the load equally diffused over its whole horizontal section. But this is far from being the case. Wren's blind confidence in the ability of masonry to act in a united manner encouraged him to perch by far the greater portion of the load on the inner ends of the piers.

To make matters far worse, the good Roman manner took control again at this point, and for the sake of regularity, all the eight great arches were made equal in span, although this involved an enormous concentration of pressure upon a single corner of each pier. The two voussoir rings of the arches meet and unite at the springing and rise for some feet above it in a common impost which has, at springing level, only the bearing area of one single arch ring. Some large ashlar stones were used under these terribly restricted imposts, but one that was examined during recent repairs was found to have broken under the extraordinary concentration of pressure.

Exactly what areas and what pressures are involved are indeterminate, for each pier is split into irregular portions by fractures, some under the point of application of the stress, as above mentioned, and others between heavily and lightly loaded portions of the piers. The unit stress on the inner ends of the piers

must be phenomenally great and must remain so even after the most thorough patching and grouting has been executed unless scientific control is devised and executed to modify the application of the load.

When the work had almost reached the level of the Whispering Gallery Wren seems to have begun to realise that the weight he was placing upon the great arches and piers should be diffused if possible and, around the base of the heavy inner drum, he constructed a series of thirty-two cells with inverted barrel vaults to spread the weight of the drums upon the four arches and four semi-domes below—Figs. 5, 6, and 7. For the same purpose he extended the diaphragm walls which connect the drums and separate the cells and formed a series of thirty-two buttresses or counterforts on the outside of the outer drum. These may be regarded as extended footings to the weight of the dome drums, but as such they have proved inadequate; all are fractured, some very severely, particularly those which might have spread weight upon the four bastions. The function of the buttresses does not seem to have been grasped by modern inquirers. Their adequate repair is not even mentioned in the Commission's Report —Figs. 5 and 8. The tops of the buttresses are hidden under the roof of the church, but above roof level the radiating diaphragm walls are continued upward between the inner and outer drums to the annular ring of flooring at the sill level of the drum clerestory windows. The outer drum being much lighter than the inner one, all these radiating diaphragm walls have been fractured by the settlement of the inner drum. Above the window sills the outer drum is continued only as an open colonnade, but each column is turned into a buttress by means of a masonry web connecting its upper part to the inner drum. These webs Wren reinforced with iron embedded in lime concrete; but notwithstanding the reinforcement, the round arches and round loopholes of the masonry webs are all dislocated in a surprisingly regular manner.

The use of reinforcement and of brickwork in the inner dome and the cone which supports the lantern marks a departure from the Gothic masonic tradition of the lower parts of the building, but the masonry masses surrounding the base of the cone and the inner drum must have been designed to act as top weight to possible outward thrusts from the cone and from the sloping inner drum—Fig. 3. Although Wren chained the base of the cone and inner dome against bursting pressures, he expressed his preference for compressive and balanced design in buildings intended to last, so that the use of the outer drums as pinnacles to the thrust of the inner drum and cone is in accordance with what is known of Wren's personal feeling in the matter.

This personal feeling against the use of unbalanced masonry masses merely restrained by tensile material may also account for the use of a wooden outer dome and for the eccentric poising of the great drums upon the principal piers, the outer lightly loaded portions of which Wren probably viewed in the light of buttress masses. The piers placed edgewise to the thrust and to wind pressure are admirably adapted for buttress action, had provision been made for applying these pressures to them in a less dangerous manner.

To save Wren's domes from demolition it would be necessary to resort now to the "iron" (or steel) which he himself pronounced to be "at all adventures, a good caution" and bind in the outward leaning walls with an endless chain of reinforcement buried in their thickness. Around the central parts of the building the reinforcement would be calculated not only to resist the outward pressures of the existing building, but to form the base of a new truncated cone erected in the spaces between the roofs and the vaults where it would be out of sight from both the interior and the exterior of the building.

The function of the cone, which would penetrate the outer drum and be pinned into the inner one at a point below the drum clerestory window sills, would be to aid the thirty-two defective counterforts in spreading the weight of the drums upon the outer unloaded portions of the piers and upon the bastions and aisle walls. The cone would have a circular base at vault top level in the form of a great tension ring which would be connected with the existing defective buttresses and with the drums by means of tensile reinforcement during their repair in detail. The cone would also continue downwards to obtain the support of the side walls of the bastions and effectively distribute weight upon them—Fig. 4.

Once the pressures had been safely transmitted and diffused by these works it would be possible to deal with the problem of the main piers by replacing the existing defective rubble core with sound new material suitably reinforced to meet the excentric pressures, which cannot be altogether done away with even though they may be beneficially modified and reduced in intensity.

The design of temporary centres for the eight principal arches and of shoring for the piers would be the first work undertaken in such a scheme, the falsework being designed to facilitate access to the faces of the piers yet capable of upholding them rigidly during the operations. The underpinning of any part of the building that might be required in view of the comparatively poor foundation could be much more safely put in hand after the walls had been reinforced, the pressures diffused and the piers consolidated. The design of all new works would be preceded by a most exhaustive inquiry into the movements of the existing structural masses of the building, for the principle of scientific conservation is to amend or neutralise the damaging drift of one part by harnessing it to a mass tending to move in the opposite direction. In the case of a building of such gigantic size and importance, constructionally, historically or artistically considered, this inquiry should be conducted with the help of a series of survey drawings revealing all variations from true alignment in length, breadth and depth, and also by means of a series of experimental models tested to cracking point under pressure to ensure that the movements in the great structure are fully comprehended by all concerned in the repairs.

In addition to the benefit to the building, a comprehensive scheme of repair would reveal many statical facts that are either unknown or have been forgotten with the disuse of vaulted methods of construction. What can be learned from patching has been known for two thousand years, and the Commission's report acknowledges that the proposal to patch will lead to the demolition of the building in due course.

Shannon Power Scheme.*

IT is not wise to discuss a subject critically before it is presented by its authors in a complete and finished form. This would in the ordinary course be a reason for remaining silent on the subject of Messrs. Siemens-Schuckert's proposals in regard to the Shannon, and would have precluded me from making reference to them, but that the Minister for Industry and Commerce elected to submit to the Dáil an outline of these proposals, although on his own admission he had neither the complete report of the German firm nor the complete report of the foreign experts employed by the Government.

The inception of the Shannon scheme, as described by the Minister, was, he said, "based on a tentative scheme submitted to the Irish Free State Government in January, 1924, which itself was based on the very valuable work of Mr. J. Chaloner Smith, and the extremely accurate Ordnance Survey maps."

At the time the Government were entering into a contract with this celebrated firm of electrical machinery manufacturers, to design the hydro-electric scheme for the Shannon, it was principally an electrical problem they had in contemplation.

The eyes of the experts seem to have been opened on their first visit to Ireland in October, 1924, to the fact that there were other important issues to be considered outside electrical problems. The Minister further says:—"But the experts have been so convinced by their journeyings in the country that the drainage of the area is necessary that they recommend the Government to proceed at once with the whole Shannon drainage scheme, portion of which will be incidental to the development of power, and some of which would not ordinarily be attempted as an adjunct of power development until the fullest possible stage of development was reached."

The journeyings referred to took place in October, 1924, during the first visit of the experts to Ireland. It is obvious that the cost of the drainage works is not included in Messrs. Siemens-Schuckert's estimate, and there can be no doubt that if their works are carried out without those referred to by the experts, the flooding of the Shannon catchment basin will be increased and not diminished.

The Minister in his speech to the Dáil paid a just tribute to the work done by Mr. John Chaloner Smith, the Assistant Engineer of the Public Works Department, in connection with the flow of water in the river Shannon, and of the value of this work to Messrs. Siemens-Schuckert in the preparation of their report.

To the casual reader or the non-technical hearer, the Minister's speech would imply that the Siemens-Schuckert scheme for the supply of power for the whole of the Free State met with the approval and support of an Irish engineer who had specialised in a study of the river Shannon.

On January 6th, 1919, Mr. Chaloner Smith read his paper before the Institution of Civil Engineers of Ireland, entitled "Notes upon the Average Volume of Flow from Large Catchment Areas in Ireland: The Probable Duration of Stated Rates of Flow, &c., Deduced from Gaugings of the River Shannon at Killaloe."

At the close of this most valuable paper he summarises his conclusions as follows—see pages 64 to 67 of Vol. 45 of the "Transactions" of the Institution of Civil Engineers of Ireland:—

"In conclusion, it may fairly be asked what, in the writer's opinion, are the prospects for a large development of water power in Ireland? To this he would reply that if the term 'large development of water power' is meant to embrace great hydro-electric schemes to develop five, ten, fifteen or twenty thousand continuous brake horse-power, the prospects are nil, as these powers, or the potentialities of them, do not exist in Ireland within the range of any reasonable expenditure. As an illustration, let us consider what may not inaptly be termed the Great Shannon Myth, as to untold thousands of horse-power being allowed to run to waste day in, day out, between Killaloe and Limerick," &c.

I do not agree with Mr. J. C. Smith's pessimistic views as to the possibility of using the Shannon for water power purposes, but I do agree that such power is limited. I adhere to the views of the Water Power Resources of Ireland Sub-committee that with the storage fixed by them and determined by the needs of drainage, a certain limited power can be counted on; but it is not possible to count on the utilisation of the mean flow of the river without extensive flooding.

In criticising the scheme put forward by Messrs. Siemens-Schuckert, it is only fair to admit that the time limit fixed for the preparation of their scheme and for their report thereon was so short that nothing in the shape of a well-considered scheme could be looked for from the German firm.

It was not until February, 1924, that they came into direct contact with the Free State Government, and they undertook to have their report handed in by September 1st, 1924. Six months was therefore the time at their disposal to study, survey, estimate and report upon the Shannon requirements.

The experts appointed to report on Messrs. Siemens-Schuckert's proposals had only two months—October and November—to visit Ireland, study the problem, examine Messrs. Siemens-Schuckert's proposals, and report thereon. To those really acquainted with this difficult problem, the time available for the contractors and the judges was ridiculously inadequate. It accounts for the superficial examination which is apparent on the face of the statements made by the Minister to the Dáil.

Perhaps nothing in the Minister's speech betrays the cursory and imperfect investigation of the Shannon problem by the German firm more completely than the references to the adoption of "a single large step" between Killaloe and Limerick. It is best to quote his own words:—"They (the experts) have proceeded on the basis that the only economic use of the power avilable, allowing for the fullest development afterwards, was by means of a canal, which diverted the water from the present bed of the river and made use of the total fall of 100ft. between Lough Derg and Limerick in one single large step. That is really the basis and foundation of this scheme, and it is the point at which it diverges completely from previous reports as to how the power of the Shannon should be utilised, and it is the point upon which it is in conflict with certain propositions put forward for the utilisation of both the Liffey and the Shannon at the same time."

When the problems of the Erne and the Shannon came under the consideration of the Water Power Resources of Ireland Sub-committee in 1919, the question of treating these rivers in steps instead of single falls was brought under their notice, and they had the whole subject carefully examined by an engineer of great experience, who had previously been associated in the design of single-fall schemes for both these rivers.

The result of his investigations was a complete vindication of the proposal to deal with both of these rivers by steps, and not by single step falls, and to develop power by barrages and power stations erected along the course of the river.

In the case of the Shannon catchment basin, all our experience points to the need of drainage taking precedence of all other interests. The production of power must obviously take second place. After the floods of 1861 Mr. Bateman reported to the Government that to relieve the lands from flooding would cost £290,000. Those works were not carried out, and now their cost would be about £900,000. As regards the Shannon, this is the direction in which the Government should move, and postpone power problems in the Shannon until they know what water will be available after the land has been properly drained.

The order of works on the Shannon would, in my opinion, be:—(1) Drainage works; (2) power development; (3) fisheries and navigation.

It is obvious that the drainage problem came upon the experts as a complete surprise on their first visit to the Shannon early in October, and it is not at all surprising that they should draw attention to the need of immediate steps being taken by the Government to deal with the drainage, although they point out that its consideration was outside their terms of reference.

The moral of the whole story is that the pressing and urgent problem is the drainage of the Shannon basin. When this is done, we shall be in possession of the knowledge of what water will be available for power purposes. It cannot be too strongly pointed out that in all probability the floods in the Shannon will increase as the drainage of the adjoining bog lands is improved. At present, the bogs act as sponges, and retain the water until they are charged. It is when they become saturated that floods occur; but, as deep bog drainage progresses, the saturation of the bogs will cease, and the rain will be discharged more rapidly into the river, and the present lag will be reduced.

The Shannon scheme, as submitted by Messrs. Siemens-Schuckert to the Executive Government of the Irish Free State, contemplates the supply of current from a single power station on the river Shannon near Limerick, and its distribution over the area of the Free State at a low price. The proposition means that the Free State, as regards electric power, will "place all their eggs in the one basket." The whole electric service for lighting and power to every large town and industry in the Free State is to be dependent on one source of supply.

It is almost inconceivable that such a proposition should be listened to by any responsible executive authority in this country. The failure of the station from any cause whatever would paralyse the whole country. We have had the experience of what it means to destroy a single bridge on a main line of communication, such as the Mallow Viaduct, and this would be child's play in comparison to the effect of cutting off the electric service of the country at large, which would result from the destruction of the power station or of the lines of communication and transmission.

No such wild-cat scheme has ever been before suggested in this country. More than half a century ago it was proposed to supply London with water from mid-Wales. The whole scheme was magnificently worked out, but Parliament declined to allow the Metropolis of the country and the seat of Government to be dependent on a water supply which was open to destruction in a time of civil commotion. We cannot shut our eyes to such risks, and it is one of the many reasons against the adoption of the Siemens-Schuckert proposals.

* From "Notes on the Siemens-Schukert Shannon Power Scheme," by Sir John Purser Griffith.

A REPORT from Constantinople states that an American company has obtained a concession from the Persian Government for the building of a railway line from Teheran to Tabriz. The company is also seeking to obtain a concession from the Ottoman Government for the construction of a line from Trebizond to the Persian frontier.

Railway Matters.

THE demands of the National Union of Railwaymen and of the Railway Clerks' Association will be discussed between the representatives of those unions and of the companies on February 3rd.

FROM a return published by the railway companies, it appears that for the whole of the year 1924 there was an increase of £748,100 in the passenger receipts as compared with 1923, but a decrease of £3,880,300 in freight receipts or a total decrease of 1.6 per cent.

SEVERAL passengers were injured in a buffer-stop collision at Glasgow Central Station on Saturday last. The impact must have been very severe, as the station is fitted with the latest form of hydraulic buffer stops, and yet there was telescoping of the vehicles.

WE are officially informed that the directors of the London and North-Eastern Railway have appointed Mr. Mr. G. B. Barton to the position of district engineer, Boston, as from January 1st, 1925, in succession to Mr. A. Burridge, who is retiring owing to ill-health.

BECAUSE of tramway competition the London and North-Western Railway some twenty years ago closed the stations on the loop line between Staleybridge and Diggle. There are four stations—Millbrook, Micklehurst, Friezland, and Uppermill—but the loop is used only by express passenger and freight trains; the stopping passenger trains use the older line through Mossley. An agitation has now been started for the reopening of the four stations.

FOR the assistance of manufacturers and traders throughout the British Isles, the London, Midland and Scottish Railway Company has issued as a booklet a classified list of its goods stations in 2592 towns, together with a large key map, 3ft. by 2ft., showing their positions on the system. In addition, information is given regarding bonded stores, warehousing accommodation, &c., with an offer of help in the finding of factory sites adjoining railway lines suitable for any manufacturing purpose.

IN anticipation of a trade revival in 1925, work on new rolling stock is being pushed forward by the London, Midland and Scottish Railway. At the company's locomotive works at Horwich twenty four-cylinder superheater passenger engines are now being finished off, and their completion will be immediately followed by the construction of twenty further engines. These latter are to be 4–4–0 compound passenger engines of Midland design, with shortened chimney, dome and cab, in order that they may pass through any tunnels and bridges on the London, Midland and Scottish system.

THE directors of the London and North-Eastern Railway Company have sanctioned an extensive scheme of alterations at Cambridge. The platform of the passenger station, already one of the longest in the country, is to be lengthened considerably, and the old Newmarket line, which has been used for the storage of carriages, is to be handed over to Jesus College and the corporation for a new arterial roadway. The new scheme also provides for the concentration of signalling work, the provision of new up and down goods yards, and the entire re-arrangement of the tracks at this centre.

THE appointment of Mr. W. J. Smith as superintendent of works, carriage and wagon department, London, Midland and Scottish Railways, for Derby, Stoke, Crewe and Plaistow, announced in this column last week, is the last of a series of promotions arising from the sudden death of Mr. F. E. Gobey, the carriage and wagon divisional superintendent at Wolverton. Mr. C. L. Mason succeeded Mr. Gobey at Wolverton, and Mr. E. J. H. Lemon, the works manager at Derby, went to be divisional carriage and wagon superintendent at Newton Heath and Earlestown, and now Mr. Smith succeeds Mr. Lemon.

THE National Wages Board, on December 28th, 1923, substituted a minimum payment for four hours in place of a guaranteed day for railwaymen called out for duty on Sunday. An appeal for the restoration of the former full day has recently been heard, and on the 22nd inst. the Board refused the appeal. Profiting apparently by its experience a little over a year ago, the enginemen's society's representatives have signed a minority report. The National Union of Railwaymen's representatives signed the report. We notice that the minority report claims the full day because "the men concerned may be called upon to perform a full day's work."

SOME apparently quite unnecessary alarm has been raised in railway trade union circles in connection with the enlistment of railwaymen in the Engineer and Railway Staff Corps. The revival of these volunteer regiments was mentioned on page 967 of our issue of December 19th, in connection with the promotion of Sir Herbert Walker to the position of Colonel in the Corps. The purpose is to have ready, in the event of war, practical railwaymen trained in bridge building, laying track, signalling, telegraphs, locomotive repairs, &c., but who shall also be qualified soldiers and be in the Army Reserve. The unions are annoyed because the officers of the railways have been permitted to select the men who are to join, and, further, they state that the men will "be legally liable to be called out in aid of the civil power." On the latter point it is clear that the unions have been misinformed.

DURING the month of October last there was a decrease, when compared with October, 1923, of 3,000,000 in the number of passengers conveyed at full fares, but an increase of nearly 4,000,000 in those carried at reduced rates. The result was an increase of 0.7 per cent. in the total number of passenger journeys. The receipts were, however, up by 5.7 per cent., and, moreover, this was gained by only 0.6 per cent. more passenger train miles. The Ministry of Transport railway statistics, issued as a Stationery Office publication, also show that the total tonnage of the freight traffic decreased by 5.3 per cent. Actually merchandise and live stock traffic was higher, but these better features were negatived by a decrease of 11.5 per cent. in coal, coke and patent fuel. The ton mileage was 2.5 per cent. less, freight train mileage 0.8 per cent. less, and the average train load fell from 134½ to 132 tons, and the net ton miles per engine hour from 457 to 438. Freight receipts were 1.6 per cent. less.

Notes and Memoranda.

AT a recent conference at West Bromwich some interesting proposals were put forward for the levelling of the waste dumps in the Black Country, and their use for recreation grounds or afforestation.

A DESCRIPTION is given in the *American Machinist* of January 24th of an ingenious process for making seamless hollow steel balls for bearings. They are pressed out of sheet metal or tubing, and weigh about 60 per cent. less than a solid ball.

AMONG several interesting articles appearing in the first issue of the *Technical College and Polytechnic Times*, which is being published by Walter King, Limited, of Fleet-street, there are a historical account of the growth of the Regent-street Polytechnic and descriptions of several provincial technical colleges.

DURING last year some extensive aerial surveys were made in Canada. One, over northern Manitoba and Saskatchewan, covered approximately 2810 miles, and over 1700 photographs were taken. With the aid of a ground traverse, these photographs will enable an area of some 15,000 square miles to be plotted. The work was completed in four weeks, but, on account of bad weather, only 44 hours 10 min. of actual flying was done.

CENTRAL heating has been adopted in Canada to a considerable extent for groups of institutional buildings. As representative of the large central heating installations may be mentioned the University of Toronto, twenty-seven buildings; the Parliament Buildings, Ottawa, seven buildings; McGill University, Montreal, nine buildings; Alberta University, Edmonton, eighteen buildings; and Queen's University and Kingston Hospital, Kingston, twenty-two buildings. Examples of community heating in Canada are to be seen principally in the cities of Toronto and Montreal.

THE Secretary for Mines announces that, as part of its inquiry into the possibility of improving the present official tests to which explosives are submitted before they are "permitted" for use in gassy or dusty coal mines in Britain, the Safety in Mines Research Board arranged for seven typical British "permitted" explosives to be put to the official tests applicable to American "permissible" mining explosives. Though the full reports of the tests have not yet been received from America, the Board has been officially informed that all the British explosives passed the American tests.

THE possibility of manufacturing carbon black from oils by an electrical process, which possesses advantages over present methods of making this important industrial material by incomplete combustion of natural gas, is indicated as the result of experiments conducted by the Department of the Interior at the Pittsburg experiment station of the Bureau of Mines. Details of these experiments are described in Technical Paper 351, by J. J. Jakosky, copies of which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D.C., at a price of 10 cents.

LECTURING before the British Acetylene and Welding Association recently, Professor C. R. Darling said that the whole subject of fluxes wanted going into from a proper scientific point of view, so that there might be less of the mystery compound than at present. There were many fluxes for various metals, but when they were analysed, no doubt they would be found very simple compounds, and were charged at about ten times the price that ought to be charged for them. If the whole subject of the action of fluxes was properly tackled—which was no doubt partly physical and partly chemical—there should be no good reason why the best flux for welding certain metals should not be arrived at.

BY the provisions of the Treaty of Versailles after the war, eighty sets of cable ploughing tackle were handed over by the Germans to the French as reparations. Machinery of this type was ideal for bringing back into cultivation the land devastated by the war, and for ploughing up large areas quickly to assist in the French re-settlement schemes, and it was expected that these ploughing tackles would play a large part in restoring the devastated areas. When the machinery was set to work, however, it was found that the outputs obtained were very poor, and in a year or two most of the tackles were laid on one side as unsatisfactory. At the same time, British machinery of the same type supplied to France before the war still continued to work, and give satisfactory results, in the same districts and under similar conditions.

ALTHOUGH it has been found on the Continent that bone charcoal is the best material for filtering beet sugar, none of the factories in this country has, according to the *Chemical Trade Journal*, a plant for the purpose. The main constituents of bone charcoal are about 10 per cent. of carbon finely disseminated throughout a porous structure of phosphate of lime, which constitutes about 80 per cent. of the material. The remaining 10 per cent. is made up of unimportant mineral constituents and water. By a process which is imperfectly understood, the carbon removes the colouring matter, whilst the porous structure of phosphate of lime removes the other impurities. By the use of animal charcoal, the sugar refiner is able to produce from the raw material, whether it be of beet or cane origin, white refined sugar of 99.99 per cent. pure sucrose content.

FLOORS constructed of joists embedded in concrete are, according to *British Industries*, economical and efficient. This method of construction is particularly reliable because the stability of the floor does not depend upon the concrete, and therefore less upon the human factor. Floors of reinforced concrete are frequently used instead of the older joist-concrete floors, although many firms of great experience maintain their faith in the latter type. This faith is justified, and there is a tendency to revert to the practice of constructing floors of joists embedded in concrete, particularly if the building is of steel-frame type. Some tests—inspired by and carried out at the National Physical Laboratory for Redpath, Brown and Co.—on joist-concrete floors prove that such floors are considerably stronger than theory shows, even with the use of inferior concrete, and it is hoped that these tests will re-establish the faith in this method of construction.

Miscellanea.

AN oil storage plant is being put up at Toronto for supplying fuel oil to vessels plying on the Great Lakes.

THE bridge at Boothferry, which is to be built to carry the new Hull–Doncaster road over the river Ouse, will cost about £112,500.

THE Quay at Newcastle is to be extended by the additioy of five more deep-water berths at a cost of approximateln a million sterling.

IT is proposed to augment the electricity supply of Coventry by means of a bulk supply taken from the Warwick generating statioa.

A LARGE deposit of monazite sand is said to have been discovered in the El Dumeral Valley of the Stanley River, near Renison Bell, Tasmania.

IT is suggested that a deep water port, for shipping coal from the Kent collieries, may be constructed about half way between Margate and Herne Bay.

TWO new British air routes—one between Stranraer and Belfast and the other between Carlisle and Belfast—will be opened for regular traffic on March 3rd.

A BEET-SUGAR factory, capable of utilising 1200 tons of roots a day, is to be built on the bank of the river Yeo, near Yeovil. It is to be ready for next year's crop.

AFTER nearly twelve months' experiment, it is announced from Barrow, that it has been decided to discontinue the Johnstone Line steamer service between Barrow and New York.

THE Great North Road is to be improved in and about Wansford, Northamptonshire, at a cost of £100,000. The works will include new bridges over the railway and the river Nene.

THE power-house at Bendigo, Victoria, has been extended by the addition of two 1750 kVA Brush-Ljungstrom turbo-generators. Current is generated at 6600 volts and 50 cycles.

IT is stated that operations have been started at the Bentley colliery, near Doncaster, for opening up the Dunsil seam, which is believed to be about 5ft. thick, and 20 yards below the Barnsley bed.

ABOUT 400 miles of main highways were completed in Alberta during 1924 under the five-year programme authorised by the Legislature. The programme for this year contemplates the building of about 500 miles of highway.

THE Institute of Patentees is organising the third annual exhibition of inventions, at which prizes will be awarded, to be held at the Central Hall, Westminster, from Monday, June 8th, to Saturday, June 13th, inclusive.

EARLY in December a new factory for making welded steel pipes was opened at Williamstown, Victoria, by Thompson and Co. (Castlemaine) Pty., Limited. It is capable of producing pipes up to 46in. in diameter by 30ft. long.

ARRANGEMENTS are being made at Birmingham University for the establishment of a School of Sugar, in connection with the Department of Brewing. The new departure will involve a training not only in academic chemistry and physics, but also in engineering.

A BED of high-grade asphalt is reported to have been discovered in the Lac la Nonne district of Manitoba, on a farm 3 miles from the site of the Nakamun oil well. The deposit is about 1½ miles south of Lac la Nonne, and is 18 miles north of the Canadian National Railway. There are out-croppings of pure asphalt in many places, and one seam measures 4ft. thick.

THE coal-handling plant which is to be put up for the Government at Port Sudan, by Sir Wm. Arrol and Co., will comprise four large bridge transporters on the Temperley principle, each exceeding 400ft. in length, and arranged with slewing motion, so that a large storage area may be covered. The grabs will be of 2 tons capacity, and the machines will be electrically driven.

WITH a view to supplying 500 E.H.P. to Trichinopoly early in 1926, the demarcation and survey of the lands required for the hydro-electric Power Company of Trichinopoly on the Kollimalais hills are, says *Indian Engineering*, now in progress. Practically only a small anicut will suffice under the high head of 2000ft. available for the development of this quantity of power, and consequently comparatively little capital—probably about Rs. 5 or 6 lakhs—will need to be expended.

IT is announced that the Suzuki Shoten, Kobe, intends to transfer part of its steel manufacturing plant from Kobe to some place in South Manchuria. As a result of an agreement with the South Manchuria Railway, which will supply Fushun coal and electric power at a low rate, the Suzuki company will engage in refining iron produced by the Anshan company. The railway company will also allow the new concern to use the buildings formerly occupied by the Fushun Iron Foundry. The output will mostly be purchased by the railway.

THE Institution of Electrical Engineers has had presented to it by the Institution of Gas Engineers an engraved plate for the production of a presidential certificate. The first impression from it was handed over by the president of the Gas Engineers, Mr. J. Ferguson Bell, M. Inst. C.E., chief engineer to the Derby Gas Light and Coke Company, at a recent meeting of the Institution of Electrical Engineers, which was presided over by Mr. W. B. Woodhouse. The recipient was Dr. Alexander Russell, F.R.S., president of the Institution of Electrical Engineers, 1923–24.

THE first of two 1200-ton steamers under construction for the Commonwealth Lighthouse Service was launched at Cockatoo Island dockyard early in December. She is 235ft. in length, with 35ft. moulded beam, and 22ft. 6in. of depth moulded to the upper deck. The vessel is to burn either coal or oil fuel. A cellular double bottom has been fitted for the whole length for carrying oil fuel and also water ballast. The main propelling machinery is of triple expansion engines, and is designed for a sea speed of 13½ knots. The requirement of the lighthouse service was a speed of 10½ knots on a steaming radius of 3000 miles.

NEW COAL STAITH AT WHITEHILL POINT ON THE TYNE

MR. R. E. HINDMARSH, M. INST. C.E., NEWCASTLE-ON-TYNE, ENGINEER

(*For description see page* 141)

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SIXTEEN-PAGE SUPPLEMENT—"THE METALLURGIST."

DEATH.

ON January 28th, at Beechgrove, Redhill, Surrey, after a long illness, CHARLES HENRY WORDINGHAM, M. Inst. C.E., C.B.E.

The Metallurgist

A MONTHLY METALLURGICAL SUPPLEMENT TO "THE ENGINEER" IS PRESENTED FOR THE FIRST TIME WITH THIS ISSUE.

THE ENGINEER.

JANUARY 30, 1925.

Work, Chip and Tool.

THE two papers on the cutting action of tools presented last Friday before the Institution of Mechanical Engineers will no doubt be found, by those seeking the opportunity, to provide a ready occasion for the disparagement of scientific investigation into familiar practical matters. Such critics, if by any possibility there be any, will not fail to remark that, conformably with the wont of scientific people when studying practical problems, Dr. Stanton and Dr. Rosenhain deliberately chose to conduct their experiments under self-imposed conditions bearing no reasonable resemblance to those prevailing in practice. In no respect, they may say, does the operation performed in Dr. Stanton's lathe reproduce common machine shop practice. The operation itself, facing the ends of a thin-walled tube, may or may not be one likely to be performed in practice. It is certainly an exceptional one, and cannot be accepted as typical of practical operations in general. As for the manner in which it was performed, attention will no doubt be directed to the fact that the form of tool used was not only unusual, but was characterised by a clearance angle 50 to 100 per cent. greater than the clearance angles commonly used in the shops. Again, the familiar custom of cutting in the presence of a lubricant was dispensed with, and a cutting speed beyond all reason too low from the practical point of view was adopted. In Dr. Rosenhain's experiments, the critic will say, the departure from practical conditions was even more marked than in Dr. Stanton's. The operation performed had but an exiguous connection with anything done in the machine shop, the tool clearance angles departed in some cases by as much as 400 per cent. from practical values, and the cutting speed was only a third of the already very low value used by Dr. Stanton. Can, it will doubtlessly be asked, the results of investigations performed with such disregard for practical conditions, be expected to possess any practical value?

The captious critic who may feel inclined to ask this question will, it seems certain, be confirmed in his captiousness by the apparent poverty and lack of novelty of the deductions drawn from the experiments by the investigators. Dr. Stanton's conclusions, it might be alleged, are crystallised in the hollow sounding statement that "in dry cutting the friction is more than adequate to secure stability of the tool and that a reduction of its amount by means of a lubricant would be advantageous." Dr. Rosenhain's results, we can hear it being said, merely illustrate in scientific manner the difference between a roughing and a finishing cut, and the effect on the accuracy and regularity of the cut surface produced by varying the top rake angle of the tool and the depth of the cut. It is no doubt gratifying, the critic will say, to have workshop familiarities of a hundred years' standing confirmed by these Teddingtonian pronouncements, but mere confirmation without explanation is hardly likely to influence practice in any shape or form. Challenged to substantiate his allegation that the authors fail to explain the facts they have succeeded in confirming, our critic, in Dr. Stanton's case, would no doubt rely for an argument on the general scheme of the investigation. We would be told to begin with that the object of the research was to discover the extent to which the frictional and abrasive forces developed in the action of cutting are important factors in the complete operation. To this end, the actual experiments performed, it would be pointed out, consisted solely of measuring the horizontal and vertical forces exerted on the tool during the cutting process. In order to discover whether friction is an important factor in the complete operation, it was necessary to determine to what extent friction influenced the magnitude of the measured forces. The action and reaction between the nose of the tool and the work were therefore analysed mathematically, and equations were established involving as factors the measured forces and the coefficient of friction. It is obvious that everything subsequent to this stage depends upon the value assigned to the coefficient of friction. Basing his authority on some quite independent experiments conducted by a colleague for the Hardness Tests Research Committee, "it would appear," writes Dr. Stanton, "that μ can be taken to be 0.35." Setting aside the fact that "what the soldier said is not evidence," our captious critic might object to any assumption being made as to the value of this all-important factor, and particularly to the assumption that its value determined under static conditions is applicable under a complex set of kinetic conditions. Something, too, might be made of the argument that the manner in which a cut is taken as assumed by Dr. Stanton for the purpose of establishing his fundamental equations is contradicted by two, and but faintly supported by one of the three types of action observed by Dr. Rosenhain. Dr. Rosenhain's paper itself, admirable for its lucidity and interest, is in essence preliminary to a complete investigation, and is almost wholly descriptive and scarcely at all analytical. It is an intriguing paper. Take, for example, the wedge of highly deformed metal found between the tool nose, the chip and the work when the conditions were such as to produce the "flow" type of chip. Dr. Rosenhain observed that, after annealing, the deformed zone assumed the normal microstructure of the surrounding metal in the chip and work, and that it was completely continuous with both. Obviously, this wedge of deformed metal is a most important factor in the mechanism of cutting. Until we are fully acquainted with all the stages in its history, we cannot pretend to understand the elements of the action going on between tool and work. Yet beyond demonstrating its existence, Dr. Rosenhain tells us very little about it. He leaves us airily guessing as to what becomes of it. The limitations of his experimental method are such that, of necessity, we are compelled, as it were, to essay a conception of a cinematograph plot from a single one of the numerous successive stationary pictures of which the film is composed. Does the matter of which the wedge consists ultimately form part of the work or the chip? If it follows either course, why does its deformed nature disappear? Is the heat generated by the cutting action sufficient to anneal it shortly after it has been formed? Or does the matter in the deformed zone adhere ultimately neither to the work nor the chip, but fall away separately as dust? Or are we to believe that the particular particles in the zone at any one instant remain in it

throughout the whole of the cutting process, that they are carried forward on the nose of the tool round the periphery of the work in a wave-like manner, and that they are continually welding up with the fresh cut surface of the work? The critic seeking answers to these pertinent questions will find no enlightenment in Dr. Rosenhain's present report. The solution may be reserved for the future.

Many will no doubt feel inclined to echo Mr. Vernon's plaintive request to Dr. Stanton and Dr. Rosenhain for some indication as to what facts revealed in their reports are new. Equally as many will, we hope, sympathise with the authors' unwillingness to commit themselves to a statement on this point. The scientific elucidation of familiar phenomena is a slow and tedious business, in spite of the rapidity with which great and illuminating steps seem at times to be presented to us. We are still plodding painfully in the matter of hardness after a hundred years of research. Many of the most important elements of fatigue in metals still baffle us, in spite of the intensive investigation of recent years. We still know but little definitely regarding some of the chief features of friction and lubrication. The fundamental phenomena of grinding and polishing are even now but dimly perceived. There are certain primitive features in the welding of iron and the casting of metals which still await scientific explanation. These and many another phenomenon, familiar in the workshop and the field, are far from being fully understood scientifically. Yet compared with some of them a study of the elementary action of cutting tools presents a problem of extreme complexity. For any impatience that may be shown over the elucidation of that problem, the obvious importance of reaching a solution may be advanced as a good excuse. In the course of its solution, we must tolerate a certain amount of repetition, a certain departure from the strict letter of practice, a certain temporary incompleteness in the stages by which advance is made. The scientist no doubt needs the guidance of the practical engineer, if his investigations are to be of real benefit and ready application to practice. But too severe a restraint upon the scientist, too much insistence that he should follow a narrowly delimited path, will inevitably prejudice or defeat the attainment of the end in view.

Fatigue and Shock.

THE effect upon metals of rapidly repeated loading, whether pulsating or definitely alternating between compression and tension, is still a matter of first-rate importance to many engineers. It has rightly received a large amount of attention at the hands of research workers during the last few years, and the true explanation of the inner mechanism of fatigue failure is, indeed, a burning question among a large group of investigators. The older views are to some extent discredited by newer researches, while the newer theories are still struggling for acceptance. We do not propose to discuss these theories, which are sometimes highly abstruse, for while we attach the greatest importance to the laying down of a sound theoretical foundation for our knowledge of materials, the engineer is more directly concerned with the facts relating to their behaviour. Even in this regard there has been a change as the result of recent investigation. For a long time it was believed that so long as the working stresses in a metal lay well within the "elastic limit" there could be no risk of failure from repetition of those stresses, however much multiplied. This view is no longer tenable, since it has been shown that metals can be made to break under prolonged alternating stresses well within the "elastic limit" as determined by a delicate extensometer. The whole value of "elastic limit" determinations has, in fact, been largely discredited, in regard to the fatigue properties of materials, since it has been found that the value for an elastic limit depends on the past history of the material. Indeed, it may undergo serious change—up or down—in the course of the service, particularly if the material is subjected to reversals of loading.

Hence it would seem to follow that the only satisfactory way of ascertaining the fatigue-resisting properties of metals is to determine them by actual fatigue tests. In all important cases there is no escape from this course, which—in view of the lengthy tests involved—is not a welcome one for practical purposes. But in less important cases two ways of escape exist. One is to rely upon the fact, which seems to be well established for steel of good quality, that the fatigue range or limit of safe alternating stresses is never less than 40 per cent. of the ultimate stress in tension. The other is to obtain data on fatigue resistance by means of the rapid "deflection" method developed by Gough. Unfortunately, both courses require complete confidence in the quality of the steel, since under Gough's test local defects, due to slag enclosures, &c., do not necessarily make themselves felt as they would do under a true endurance fatigue test or under conditions of service. When, therefore, we place our dependence on a relationship of this kind, we must satisfy ourselves completely as to the general quality of the steel, and particularly as to its freedom from physical defects. There is probably no better way, if there is any other way at all, of obtaining certainty as to the quality of steel from this point of view than well-conducted macroscopic and microscopic examination of etched sections. The only real difficulty about these methods is that of expressing the results quantitatively, but even in the absence of numerical data quite definite information can be obtained by their aid, and we believe that already this aid is being used by a large number of engineers. It is, essentially, a matter of confidence, and that confidence has begun gradually to establish itself. There is, however, another point which appears to have received very little attention hitherto. Fatigue tests by any of the well-known methods determine the resistance of the metal to fracture under steadily alternating loads—indeed, vibration and shock are most carefully eliminated from tests of this kind because their influence is known to vitiate the results. No doubt, this practice is quite right from the point of view of scientific investigation. Even for testing purposes it may be desirable to determine one property at a time. It must, however, be borne in mind that in actual use there are many cases where shock and fatigue are at work together. In smooth-running machinery working under good conditions it is true that there is little or no shock, and the pure fatigue properties of materials are alone involved. On the other hand, there are many circumstances where it is the combination of fatigue with more or less frequent shock which constitutes the normal working conditions. The springs of a motor car or lorry are typical examples of parts exposed to flexural fatigue stresses combined with shock. When fracture occurs it is usual to ascribe it to shock, but we do not really know at present how far the application of occasional shock affects the fatigue resistance of steel or other metals. Another typical example of the combined action of shock and fatigue is found in the propeller and axle shafts of the motor car. Here we have parts normally exposed to pulsating torque, varying, during smooth running, from zero to a maximum value or at times through a much smaller range; only rarely are the torsional stresses actually reversed as under severe braking or running in reverse. On the other hand, torsional shocks are very apt to occur as the result of misfiring or sudden starting or stopping of the engine, or unduly violent use of clutch or gears, and here, again, we do not know how such shocks affect the fatigue behaviour of the parts. In this connection the curious experiment made by Dr. Hatfield, described in the Metallurgical Supplement ("The Metallurgist"), which appears with this issue of THE ENGINEER, is worthy of attention. A back axle of mild steel was used and twisted nearly through a complete circle without failure.

When breakages occur—as they still sometimes do—are they due to the material being too soft and weak to resist the steady fatigue action or because it is too hard and brittle to withstand the shocks? It would seem that we have here an urgent case for investigation, or, rather, for determination, of the combined effects of shock and fatigue, since at present the engineer is left to make a compromise somewhat in the dark. It is a matter which may be commended to the attention of investigators, or perhaps to such a body as the Springs Investigation Committee of the Department of Scientific and Industrial Research. The data obtained might not perhaps be capable of immediate scientific interpretation, but they should be of immediate value to the engineer in his choice of materials for particular purposes.

SIXTY YEARS AGO.

IN our issue of January 27th, 1865, in a leading article entitled "Petroleum as a Steam Fuel," we argued strenuously against the suggestion which had recently been revived that under the conditions then existing petroleum could with advantage be used as a substitute for coal as a steam fuel in the Navy and the mercantile marine. "Truth," we wrote, "has often been driven to the wall for a time by the most insignificant foe that ever manufactured a cut-and-thrust sword from a wheaten straw or worked up a theory from an ounce of moonshine." The proposed substitution, we held, was one of the most plausible fallacies of the day. It was first suggested by certain oil-well speculators in New York, but although the American Naval Bureau was induced to experiment, nothing came of the suggestion in practice. In Great Britain advocates of petroleum as a fuel were urging that its reduced bulk per thermal unit would effect an important economy of space, that the greater convenience of its application would permit of a reduction in the number of stokers required, and that it would materially increase the evaporative capacity of existing boilers. All these assumptions, we held, were erroneous. Figures were deduced to show that petroleum far from possessing five times the thermal energy of the same weight of coal, could not possibly on its analysis possess more than about 1½ times. Again, we argued that a ton of petroleum would occupy almost exactly the same space as a ton of coal. While admitting that for the same power the use of petroleum would result in a certain economy of bunker volume, we questioned whether this advantage would compensate for the inconvenience of having to store and handle an inflammable liquid in bulk. We anticipated that the difficulty of preventing the evaporation of the volatile constituents of the oil would, as in the case of a vessel that had been fitted with the Du Tremblay ether engine, necessitate the lighting of the engine-room by means of Davy lamps. As for the convenience alleged in the use of petroleum, we dismissed it as "utterly absurd," chiefly, apparently, because no reasonable form of burner had so far been devised and because of the difficulty foreseen in maintaining a constant rate of supply from the bunkers when they were but partially full and the vessel was pitching in a heavy sea. The suggested increase in the efficiency of existing boilers would, we held, not bear a moment's investigation. It was possible that the evaporative power, by judicious management, might be slightly augmented, but the economical efficiency would show a remarkable falling off. All the heat which existing boilers could utilise, and which the furnace plates could bear, could be produced from coal under normal conditions of draught. It was impossible to detect any prospect of material advantage following the production of higher temperatures in marine furnaces.

FUEL CONSUMPTIONS OF STEAM AND OIL-ENGINED VESSELS.

IN a paper read recently before the North-East Coast Institution of Engineers and Shipbuilders, Mr. Sterry B. Freeman gave some interesting figures relating to the use of fuel oil aboard ship, taken from the logs of some eight vessels in the service of Alfred Holt and Co. Several of these vessels belong to similar classes and their performances are therefore comparable. To facilitate such comparison the firm has long made a practice of expressing the performance of a given ship by the constant C obtained from a modified form of the Admiralty coefficient formula, in which the weight of fuel oil used per day for all purposes replaces the average indicated horse-power in the denominator of the fraction. The equation then reads $C = \frac{D^{\frac{2}{3}} \times S^3}{\text{Fuel consumed}}$, where D is the average displacement of the ship in tons for the voyage, and S the speed in knots, the fuel oil consumed being expressed in tons used per twenty-four hours for all purposes. The following particulars show the average results for various types of machinery:—

Type of machinery.	Coefficient C.	Lb. of fuel per S.H.P.
Reciprocating engines with saturated steam and coal-fired boilers	16,000	1.65
Reciprocating engines with steam superheated to 160 deg. to 200 deg Fah. and coal-fired boilers	18,500	1.5
Turbine machinery with 160 deg. to 200 deg. Fah. superheat and coal-fired boilers	19,500	1.425
Turbine machinery with steam superheated to 160 deg. to 200 deg. Fah. and oil-fired boilers	30,000	0.90
Marine oil engines, Burmeister and Wain four-cycle single-acting type	64,000	0.41
Scott-Still two-cycle oil engines, taken over one voyage	76,000	—

It may be noted that the fuel consumption for the Scott-Still engines was not taken for the single voyage referred to, but in the test bed trials described in THE ENGINEER of November 23rd a figure of 0.356 lb. of oil fuel per brake horse-power was obtained.

BOOKS RECEIVED.

The Principles of Machine Design. By R. F. McKay. London: Edward Arnold and Co., 41 and 43, Maddox-street, W. 1. Price 18s. net.

Clubs, 1925. Edited by E. C. Austen-Leigh. London: Spottiswoode, Ballantyne and Co., Limited, 1, New-street-square, E.C. 4. Price 7s. 6d. net.

Powell's Electric Supply Share Handbook. Compiled by H. H. C. Blake. London: Effingham Wilson, 16, Copthall-avenue, E.C. 2. Price 5s. net.

The Journal of the Iron and Steel Institute, 1924. No. II., Vol. CX. Edited by G. C. Lloyd, Secretary. London: Offices of the Institute, 28, Victoria-street, S.W. 1.

The Elements of Railway Economics. By Sir W. M. Acworth and W. T. Stephenson. London: The Oxford University Press, 10, Warwick-square, E.C. 4. Price 3s. 6d. net.

Supplement and Second Supplement to Punjab Irrigation Branch Paper No. 20 on Water-logging of the Soil in the Vicinity of Punjab Irrigation Canals, and Measures for the Prevention of Water-logging. Punjab Government, Public Works Department. Price 4.4 rupees or 5s. 8d., and 6 annas or 6d., respectively.

Obituary.

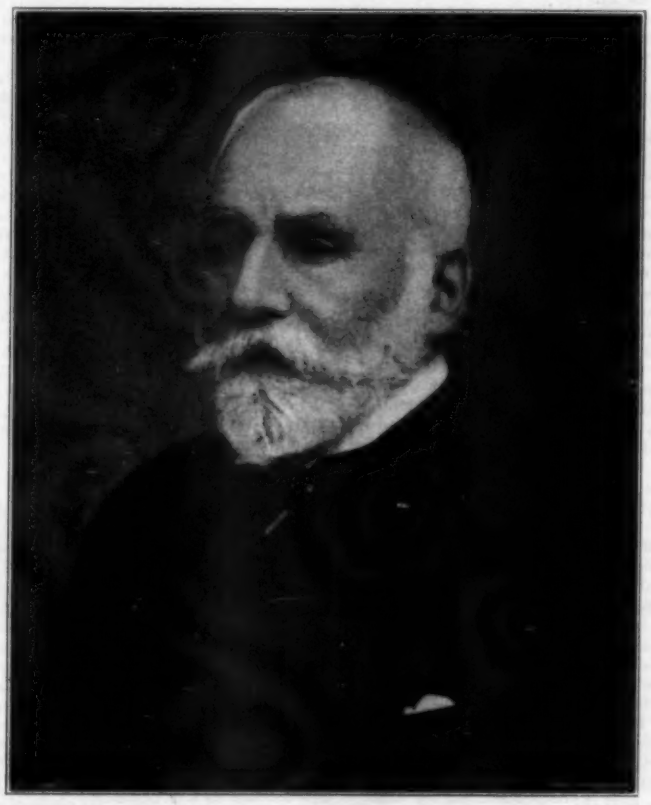
SIR GUILFORD LINDSEY MOLESWORTH.

WIDESPREAD regret is felt at the death of Sir Guilford Molesworth, which occurred at his home, The Manor House, Bexley Heath, on Wednesday, the 21st inst. The names of few, if any, engineers are better known throughout the engineering profession than is that of Sir Guilford, for though, owing to his great age and to the fact that he retired so long ago from active work, many of the younger generation, at any rate, are ignorant of the particular branches of engineering with which his name is most intimately identified, there cannot be many engineers or students of engineering who have not heard of or used "Molesworth's Pocket Book of Engineering Formulæ," which was unique when it first appeared and is still a classic among books of reference.

Guilford Lindsey Molesworth was the youngest son of the late Rev. J. E. N. Molesworth, D.D., Vicar of Minster, in the Isle of Thanet, and later of Rochdale. Guilford Lindsey, the fifth son, was born on May 3rd, 1828, and he was therefore approaching the ninety-seventh anniversary of his birth at the time of his death. He received his early education at King's School, Canterbury, and afterwards at a school in Manchester, which he left at the age of sixteen. His own wish was to enter the Navy, but his father ruled otherwise, and decided that he should become a civil engineer. He was accordingly sent to the College of Civil Engineers at Putney, having previously studied drawing with a mechanical draughtsman for a short time. While at this College, which now no longer exists, he did not, to use his own words, shine as a student from an educational point of view, though he was described by the Principal as a "a studious, painstaking person, whose conduct was uniformly satisfactory." Sir Guilford's comment on that description was that he was inclined to think that the verdict was more favourable than the facts justified. He is credited, in "The Life of Sir Guilford L. Molesworth," edited by his cousin, Miss E. J. Molesworth, with saying that he left the College perfectly satisfied that he had not much to learn about engineering; but that before he had been many weeks in actual practice he began to find that there were *some* things that he did not know, and that as time went on the number of those things increased in a marvellous way. Furthermore, he added, "and now, after a long professional career, I have achieved a knowledge of my own ignorance and a conviction that the education of an engineer is never complete." These quotations give the keynote to the man's whole career.

Young Molesworth, apparently, remained at the College for some two years, for in or about the year 1846 he became an articled pupil of Mr. R. B. Dockray, the Chief Engineer of the London and Birmingham Railway, which afterwards formed part of the London and North-Western Railway. Young as he was, he was at once made "Assistant Engineer," the first work on which he was engaged being the preparation of designs for the widening of the railway between London and Watford, which included the driving of a second tunnel under Primrose Hill. He subsequently made surveys in Buckinghamshire and was finally engaged on the construction of a branch line.

Acting on the advice of Mr. Wyndham Harding, who was at the time at work on the Summit Tunnel of the then Lancashire and Yorkshire Railway, Mr. Molesworth senior then apprenticed his son to Sir William Fairbairn. Mr. Harding had urged that a young engineer's education could not be consummated without practical workshop experience, and experience of that kind he had an excellent opportunity of acquiring in Sir William's works at Manchester, where he first worked as a millwright and subsequently as a fitter. That he must have made good use of his opportunities—did not the whole of his after life bear witness to the fact—may be surmised from the statement that before he was twenty-one he was sent to Portugal to erect an engine for driving a cotton mill and afterwards erected a 240 horse-power pumping engine in what was, at the time, the deepest coal mine in England. It may be added, as showing his own views on this matter, that in after life he was an ardent advocate of workshop training for the young engineer, even though he might never have anything to do with workshops later in his career.



SIR GUILFORD LINDSEY MOLESWORTH

For the two years 1849–50 young Molesworth acted as Chief Assistant in South Wales to Mr. Doyne, who had known him when he was on the London and Birmingham Railway. After Doyne had left this country to command the Army Works Corps in the Crimea, Molesworth was fortunate enough to be appointed Chief Assistant Engineer on the London, Brighton and South Coast Railway, in which position he had to take charge of the widening of the line between London and Croydon and the building of the Crystal Palace Low Level Branch.

Shortly after the outbreak of the Crimean War the necessity arose to appoint an engineer with a knowledge of building and machinery for Woolwich Arsenal, and Molesworth, on the recommendation of Sir William Fairbairn, was offered and accepted the post. Almost from the very first, however, he found the position untenable, as is so frequently the case when a civilian has to work under the orders of an Army officer. The official in charge of the department of the Arsenal in which he was appointed to serve was a Royal Engineer, who, naturally, insisted that nothing should be done which had not received his signature. This restriction was evidently regarded by the civilian as hampering his activities, and at length, after undergoing what, at this length of time, appear to be quite petty interferences, he sent in his resignation, though he admitted in after life that it went sore against the grain to do so. That the provocation must have been very considerable is, however, quite plain to all who knew the staunch patriotism which was one of the man's leading characteristics. It is unthinkable that, unless for very weighty reasons he would, in time of war, relinquish a post in the country's leading arsenal.

Molesworth was not to be long unemployed, however, which was well for him, for he had been married just before going to Woolwich. It is significant—as was also the recommendation for the post at the Arsenal given by Sir Wm. Fairbairn—of the good impression the young man must have made at Manchester, that his next offer—namely, to join him in partnership as consulting engineers in London—came from a Fairbairn man, Mr. Horner, who had been chief draughtsman. The partnership, which began in 1855, did not last very long, for Mr. Horner, who was an elderly man, soon retired, but his place was taken by a Mr. Edmund Edwards—still another Fairbairn man and a contemporary of Molesworth's—the style of the firm being Molesworth and Edwards and the offices at the top of Beaufort Buildings. A good deal of work done by the firm was in the design of lattice girder bridges, for which Molesworth's experience in South Wales had given him some aptitude.

Previously, in 1854, Molesworth had been elected an Associate Member of the Institution of Civil Engineers, and in 1857 he submitted to that Society a paper on "Woodwork Machinery," which gained for him a Watt Medal and a Manby Premium. During this time, too, he began seriously the compilation of his "Pocket Book," though it was a number of years later before it was first issued to the public.

Another striking instance of how ready those who had once known him were to be again associated with him is afforded by the fact that in 1859 Mr. Doyne, who had been his chief in South Wales and who after the termination of the Crimean War had been appointed Chief Engineer of the Ceylon Railway Company, advised his directors to make Molesworth their Mechanical Engineer and Locomotive Superintendent. They did so, and the young man, then aged thirty-one, proceeded to the East, a voyage which then occupied four months or so, for the construction of the Suez Canal had only just been begun and was not to be completed until 1869. He was followed three months later by his wife and family, but the stay there was not to be long. Mr. Doyne, dissatisfied with the survey and estimated cost of a line for joining Colombo to Kandy, previously proposed by a Captain Moorsom, suggested the employment of a rope incline instead of an adhesion line, and he was sent to England to submit the matter to Robert Stephenson for decision. Stephenson died before he could send in a report, and the point was then submitted to Mr. Hawkshaw. While Mr. Doyne was in England Molesworth took his place as Chief Engineer, and he obtained permission to make a survey of an entirely different route for the line about which the discussion had arisen. He ascertained that a railway with a gradient workable by adhesion could be constructed for a sum considerably less than that of the proposal put forward by Mr. Doyne. About the same time the Government offered to take over the whole railway system from the company. The directors, acting on Molesworth's advice, refused the offer, but speculators, anticipating profit if the Government acquired the concern, managed to buy-in sufficient shares to gain control and the Government effected the purchase. The railway as surveyed by Molesworth was, it may be said here, eventually carried out practically for the amount of his estimate. He himself remained in the island for some time longer to assist in the setting out of the line on the banks of the Maha Oya, but in 1861 he and his family set sail for home, never expecting to see Ceylon again.

The year 1862 was marked by three events:—Molesworth became full Member of the Institution of Civil Engineers, he returned to Ceylon, and his famous Pocket Book was finally completed. It had actually been begun as long before that as 1846, when, acting on the advice of Mr. Dockray, he had started to write down in a book anything which had particularly attracted his attention. As the years went on the book grew in size and could no longer be carried about conveniently, so that, for everyday use, another book of lesser size and containing the information most likely to be wanted in his work had to be prepared. Finally, when the main volume was completed to his satisfaction, the idea came to him to have all the data he had collected printed and bound in a book of such a size that it should be easily portable. The first publisher to whom he submitted it refused to have anything to do with it, saying that there would be no demand for such a work. But Messrs. E. and F. N. Spon very speedily came to an opposite conclusion, with the result that the Pocket Book was first published in November, 1862. It then ran to 220 pages; it now extends to nearly 950. The objects of the work and the circumstances which led up to its compilation and preparation are so ably set out in the preface to the first impression, which has been repeated in subsequent editions, and the book is so well known to everyone that no further description of it need be given here. The opening sentence of the preface, however, may perhaps be quoted, for it has come to be quite a "household word":—"Few are gifted with a memory so retentive as not to require the aid of written formulæ in working out the numerous calculations constantly necessary in the profession of an Engineer." It was to supply the deficiency that the book was planned.

During the period of two years or so of comparative leisure at home events had been moving in Ceylon. Mr. Smart, the Chief Engineer of the Madras Railway, who had been called in to advise on the question of the line between Colombo and Kandy, had reported in favour of the Molesworth route, and had endorsed its author's estimates. Accordingly we find Sir Guilford invited by the Government of Ceylon to

return as Chief Engineer of its railways, and we see him setting out for the East again with his family in November, 1862. Actually the first copy of his Pocket Book was handed to him on the railway platform as he was setting out.

Of Sir Guilford's work, first of all in Ceylon and subsequently in India, a very great deal might be written. It had to do mostly with railways, but it was by no means confined to that subject. His first duty on returning to Ceylon was to see to the completion of the Colombo to Kandy Railway, which, in spite of great natural difficulties, was successfully accomplished. Some time before the line was finished, in fact when it was only possible to travel some 30 miles from Colombo, an incident occurred which might well have cost him his life, and that of a distinguished visitor. The Duc de Brabant, who was afterwards the King of the Belgians, had been on a visit to the Lieut.-Governor at Kandy and was on his way back to Colombo. The train on which he was travelling the final part of his journey in company with many British officials was driven by Molesworth himself, and, since there was no turntable available, the engine had to proceed tender first. When running down a steep gradient on a curve Molesworth observed that in front of him some large stones had been left upon the rails. As he realised that it was impossible to pull up before the obstacle was reached, he did not attempt to reduce speed, but, on the contrary, opened the regulator to the fullest possible extent and was enormously relieved when the stones were thrust aside and the train passed by without being derailed. It was more or less of a miracle that it was not thrown off the rails, for the tender was not provided with lifeguards. The Royal passenger did not till many years afterwards know what a narrow escape he had had.

On the completion of the line Molesworth was made Director-General of Railways and Director of Public Works in the island. The task of organising the working and *personnel* of the railway was by no means light, seeing that the whole of the staff was new to the work; but it was eventually satisfactorily accomplished by the exercise of much patience and a large modicum of tact. One of the difficulties encountered and overcome was the fact that the locomotive drivers, who were at the outset Europeans, were not accustomed to taking trains down long inclines of as steep a gradient as 1 in 45, of which there were long stretches on the line. Molesworth was, all his life, against break of gauge in railway systems, and it was largely due to him that the standard gauge in Ceylon to-day is 5ft. 6in. and that there is only a comparatively short length of light line with a gauge of 2ft. 6in. It was in 1871, when at home on leave, when the question arose as to whether an extension of the 5ft. 6in. gauge line should be made with a gauge of 3ft. 6in., and his reply was so emphatic that the Governor for the time being was completely convinced that such a course would be a mistake.

Railways were by no means the only things which claimed Molesworth's attention at this period. In his position as Director of Public Works he had much other work to do. First of all, there was the reclamation and restoration of irrigation systems of a bygone time, which, owing to neglect, had long before become useless and, in fact, in many instances, had been overrun by jungle. Then again there were roads which he left in a better state than that in which he had found them, and had also added to their length, while at the same time effecting an annual saving of between £30,000 and £40,000. The harbour at Galle, which is at the south-west of the island and was then its main point of call, had to be maintained, and it was while personally superintending in diving dress the removal of rock at a depth of 40ft. that he was knocked over by a ground swell, which demonstrated to him the fallacy of the then popular belief that wave action was innocuous at greater depths than 12ft. or 13ft.

Curiously enough, in spite of the many other improvements which he either himself effected or was largely instrumental in getting carried out in Ceylon, Sir Guilford used to declare that in his view the most valuable service he rendered to the Colony was the institution of a decimal coinage. Early in his second stay in Ceylon he appears to have commenced a campaign with that object, but it was only after some five years' hard struggle that he persuaded the populace and the authorities to entertain his proposals favourably. That was in 1869. In 1870 he was ordered to proceed to England to discuss the question with the Treasury officials. His plan was adopted in 1871, and he prepared the actual designs for the first set of coins which were struck in the Calcutta Mint.

It was while in England for this purpose that he was invited by Sir George Chesney to accept the position of one of the professors at Cooper's Hill College, but, since he felt that he was not suitable to be a tutor, he decided that he could not accept the offer. Furthermore, just before he had left Ceylon he had received intimation from Sir Charles Hulton Gregory that, having been requested by the Government of India to recommend two or three gentlemen qualified to hold the appointment of consulting engineer in India to the Railway Department, he had put forward his—Molesworth's—name in such a way as to make it plain that in his opinion he was the most suitable person. Eventually he was offered and accepted the post, and then began what must in many ways have been the most interesting period of his career. It would be impossible in a memoir of this description to attempt to give more than the barest outline of the work which he carried out between his acceptance of the position and his retirement at the age of sixty years in 1888. At the very start the question of break of gauge cropped up, and he found a steadfast upholder of his views in the late Lord—then Sir Frederick—Roberts. The Afghan War, which came a few years later, amply vindicated the contention of both that in military operations, at any rate, it was of vital importance that strategic lines should be of the same gauge throughout. As a result the gauge of more than 1000 miles of line was altered. It is of interest here to note that many years later, in April, 1914, a paper on "The Battle of the Gauges in India" was read in Caxton Hall, Westminster, by Sir Guilford Molesworth, before the East India Association, and that Field-Marshal Lord Roberts occupied the chair.

During the time that Molesworth held office in India some 4000 miles of State Railways were sanctioned and nearly 3500 miles opened for traffic, which meant that on the average over 200 miles of line were completed each year, and in one particular year no fewer than 1100 miles of new railways were put into service. The work involved was enormous, and it necessitated the driving of numerous tunnels and the construction of bridges over some of the largest rivers in the country. One bridge he designed for Sukker was to have had a span of 830ft. and a rise of 150ft. It was not, however, adopted, its place being taken by a cantilever bridge designed by Sir Alexander Rendel, though it was later admitted that, owing to the difficulties experienced in the erection of the latter, it had been a mistake not to adopt the arch form. During the Afghan War Molesworth saw much service at the front, and on several occasions came very near being captured by the enemy. In 1879 he made a survey for a railway by way of the Khyber Pass to Jellalabad, and in 1880 a reconnaissance for a railway through the mountain range to Kandahar. In 1882 he was deputed to make an examination of the harbour works at Madras, which had been considerably damaged by a cyclone. Here he again found proof of the fallacy of the belief that below 13ft. or so the effect of waves was negligible. During the Burmese War he was ordered, after the capture of Mandalay, to make a survey for a railway from Rangoon to that place. In Burma he again met Sir Frederick Roberts. For the work done on this railway and on the North-West Frontier he was awarded the Burma War and the Afghan Medals. Just before he retired in 1888 he had been engaged in surveying a line for the East Coast Railway, which involved the crossing of the rivers Godaveri, Kistna, Mahanadi and Rupnarain. On his retirement he was created K.C.I.E.

Returned to England, Sir Guilford went to live at the Manor House at Bexley. But retirement did not mean for him inactivity. His abundant energy sought outlets in many directions, some of them having nothing whatever to do with engineering. He was, however, appointed to serve on a committee, the duty of which was to select engineers for the Public Works Department in India, and in 1891 he was called in by the British East Africa Company to advise on the best line to choose for a railway from the East Coast of Africa to the Victoria Nyanza. His report had to be made simply from the study of maps, for he did not visit the country and had never been there, but it is noteworthy that the route he recommended for what is now known as the Uganda Railway was followed practically in its entirety. Seven years later, when he was seventy years old, and when the railhead of the line had reached 170 miles from Killindini, he was invited by the Foreign Office to visit the line and report generally on its organisation, system of control, progress, &c. Most of his inspection was carried out either on foot or on a solid-tired bicycle and in the height of a tropical summer.

The crowning point in Sir Guilford's career was his year of office—1904–5—as president of the Institution of Civil Engineers. Though then in his seventy-seventh year, he was still hale and active, and he performed the duties of his office with distinction. His presidential address was a masterly dissertation upon India. Practically speaking, his presidency terminated his professional career. His final years, though by no means passed in idleness, were, for the most part, devoted to the study of the social and economic problems of the day, which need not here be detailed. Yet the full story of his life is not yet told. When the Great War broke out, though he was in his eighty-sixth year, Sir Guilford volunteered for home defence and was actually accepted and commenced to serve. He had, however, to retire on medical advice. In the following year, however, he volunteered for employment in the manufacture of munitions and worked as a skilled mechanic in the Vickers Works at Crayford. After five months, during which he worked daily from 9 a.m. to 4 p.m., he was again, under medical orders, forced to retire.

Of the man as a man perhaps we may be permitted to quote from a letter written recalling recollections of Sir Guilford fifty years ago in India and reprinted in the "Life" of Sir Guilford, to which we made reference above and from which a great deal of the foregoing has been culled. Two passages from the letter are as follows:—"Sir Guilford was always the youngest and most energetic of every party when there were inspections or surveys going on, soon outdistancing all other walkers. . . . I wish I could tell you of the delight that his presence gave us both whenever we met him in India or at home. The fresh interest he took in everything, his simple ways, I mean absence of every thought of himself, and his courtesy just endeared him to every one who knew him."

LORD CLAUD HAMILTON.

A LONG and distinguished career was brought to an end by the death of Lord Claud Hamilton, which occurred in London on Monday last.

Lord Claud was not an engineer, but his extended connection with the Great Eastern Railway brought him much into contact with engineers. He was the second son of the Duke of Abercorn, his mother being Lady Louisa, the daughter of the Duke of Bedford. He was born on February 20th, 1843, and received his scholastic education first of all at Bayford House, in Hertfordshire, and afterwards at Harrow. At the age of nineteen he entered the Grenadier Guards, from which he retired after five years' service, subsequently becoming Colonel of the 5th Royal Inniskilling Fusiliers. He sat in the House of Commons at various times for Londonderry, King's Lynn, the West Derby Division of Liverpool, and South Kensington.

His connection with the Great Eastern Railway Company began as far back as 1872, when he was elected a director in place of the late Lord Salisbury. He was made deputy chairman in 1875 and chairman in 1893, when he succeeded the late Mr. C. H. Parkes. During his tenure of office many improvements were carried out in connection of the line, foremost among them being the improvement and enlargement of Liverpool-street Station and the institution of steamship services between Harwich and continental ports. He was extremely popular with all grades of the staff of the line, in whose welfare he always took the keenest interest. One of his acts was very severely criticised at the time, and that was the appointment of an American, Mr. H. W. Thornton, as general manager of the company, but as the result of his chairmanship as a whole the line is in a very considerably better position now than when he first joined it.

In addition to his work for the Great Eastern, Lord Claud was for a time the chairman of the Railway Clearing House, of the Railway Association, the East London Railway Company, and of the Sheffield District Railway Company.

ALLEN GOODWYN.

THE death is announced of Mr. Allen Goodwyn, for many years one of the managing directors of Ransomes, Sims and Jefferies, Limited.

Mr. Goodwyn, who was born in 1851, was the fourth son of the late Mr. Samuel Chapman Goodwyn, of Covehithe. He served his engineering apprenticeship with Richard Garrett and Sons, Limited, of Leiston, and afterwards spent some time in Germany and Hungary, helping the agents of Messrs. Garrett's there and acquiring practical acquaintance with the use of machinery in the field. Later he was closely associated at Leiston with the development of Messrs. Garrett's export business. In 1883 he entered the service of Ransomes, Sims and Jefferies, Limited, becoming in the year 1900 managing director in complete charge of the export department.

From 1883 until the outbreak of the War Mr. Goodwyn made yearly journeys abroad. During that period he visited continually every country on the Continent, and, with the exception of the Australian Colonies, all the important countries of the world, including the River Plate, Chile, North and South Africa, India, China, and Japan, and to many of these countries he made several visits. With his knowledge of farming, which he had partly acquired as a youth, for his father farmed 6000 acres, and his experience in the practical use of machinery in the field, added to his keen business judgment, which never failed him, he had a great share during these years in building up and developing the export business of the Orwell Works.

WALTER TYZACK.

THE death took place in London last Saturday of Mr. Walter Tyzack, who was well known in Sheffield in connection with the cutlery industry.

Mr. Tyzack, who was the fourth son of the late Mr. William Tyzack, of Sheffield, was born in November, 1857, and was educated first at Bowling's Academy, and then at the Rev. Thomas Howarth's school. After some short periods spent in Norway and Sweden, he began his business career with the firm of Needham, Veall and Tyzack, in 1879, and when the firm became a limited concern, he was made the first chairman. For many years he was a member of the Cutlers' Company and the Sheffield Chamber of Commerce. He was a founder and president of the Sheffield Cutlery Manufacturers' Association; and he was also prominently associated with the Sheffield Silversmith's Association.

During the war he rendered valuable assistance to

NEW VIADUCT AT ANNAGHKILLY—GN. RAILWAY (IRELAND)

the Ministry of Munitions, and was later a member of the Board of Referees which dealt with excess profits.

In consequence of a seizure which he experienced in March, 1922, from which he never fully recovered, he gave up active participation in the business of Needham, Veall and Tyzack, and came to live in London some twelve months ago.

The New Annaghkilly Viaduct.

To cope with the loads due to increasing weights of locomotives and traffic generally, the Great Northern Railway Company (Ireland) has on hand the strengthening or renewal of a considerable number of bridges throughout its system. The latest bridge to be renewed is the important structure at Annaghkilly, near Clones, County Monoghan, on the single-line branch between Dundalk and Clones.

The old bridge was built about seventy years ago and consisted of six spans of 50ft. each, carrying the line across the boggy valley of the river Finn. It was supported on cast iron trestles, which in turn were carried on timber piles. Its condition, however, was such that for a number of years past additional temporary supports had to be resorted to to keep it safe for traffic. The girders were of wrought iron lattice type with timber cross beams resting on the bottom booms and timber decking, while the rail chairs were fixed down to longitudinal timber waybeams.

The new bridge had to be designed to meet the existing and the new conditions as far as possible. The nature of the ground was ascertained by means of bores and trial pits and was found to be soft and treacherous. It was accordingly decided to put down cylinder foundations and to sink them to the rock. To avoid any interference with the traffic the positions of the piers were fixed at points between and clear of the old trestles. There are eight piers of two cylinders each, and they were sunk by means of compressed air to depths varying from 25ft. to 60ft. below the ground level, the cylinders in all cases being founded on the solid rock. On completion of the sinking the cylinders were filled with cement concrete, the aggregate being supplied from the company's own granite quarries at Goraghwood. The concrete was reinforced with old steel rails placed vertically. The cylinders were of mild steel varying from 6ft. to 7ft. in diameter. This portion of the work was completed and made ready to receive the new superstructure early in July last.

The superstructure of the new bridge has a total length of about 400ft., consisting of seven spans of 56ft. each, and a total weight of over 400 tons. The girders, which are of the web and flange type, rest on built-up bearers fixed to the top of the cylinder piers, one end being fixed and the other end left free for expansion. They are braced by a system of cross diagonal and horizontal wind bracings throughout the whole length. The flooring is of pressed steel troughing with side ballast plates and handrailing, taking a concrete floor on which the ballast and permanent way rest.

In view of the difficult nature of the ground referred to, and of the fact that alternative routes were available for traffic to and from Clones, it was considered advisable to close the line for the erection of the superstructure, this method being considered more economical than attempting the erection under ordinary traffic conditions, which would have entailed a considerable amount of piling and staging. The work was accordingly held back until the rush of the summer season traffic was over, and in October last it was carried through to a successful finish in a remarkably short time. The demolition of the old bridge and the erection of the steel work for the new structure were completed in nine days, the riveting four days later, and the concrete flooring another day later, the whole being ready for the relaying of the permanent way in fourteen days. It should be noted that no night work was engaged in, the whole work being carried out during the hours of daylight.

The designs of the bridge—which is illustrated in the accompanying engravings—were prepared by Mr. F. A. Campion, M. Inst. C.E., chief engineer to the Great Northern Railway Company of Ireland, and the work was carried out under his direct supervision. Sir Wm. Arrol and Co., Limited, of Glasgow, were the successful tenderers and were entrusted with the contract. They were represented at the site by Mr. Thomas Lightbody, engineer-in-charge of the firm's work in Ireland.

THE ANNAGHKILLY VIADUCT DURING CONSTRUCTION

Matter and Radiation.

THIS year the Radio Society of Great Britain has been fortunate enough to secure Sir Oliver Lodge for its President. Although Sir Oliver was elected a honorary member as soon as the Society was formed, he has rarely, if ever, attended its meetings, but on Wednesday of last week he made up for his long absence by delivering an excellent presidential address, during which he told the members many things of considerable scientific interest. There were three societies in London, he said, that dealt with radiation. The Radio Society was one, the Röntgen Society another, and the Optical Society was the third. They dealt with radiation from different points of view, but they were all primarily concerned with waves in the ether.

All waves of whatever size, whether radio waves or luminous waves or X-rays, travelled at exactly the same pace, and their laws of transmission were fairly well known. To detect the smallest waves, phosphorescent material or photographic plates had to be used; to detect the intermediate waves, the physiological instrument called the eye sufficed; whilst to detect the largest waves, a rectifier such as a crystal or valve had to be employed, and with the aid of the telephone they made appeal to the human ear. Less was known about the detection of luminous waves than about the detection of the two other kinds of waves. We were all accustomed to what went on in the retina of the eye, but no complete or satisfactory theory concerning the detecting properties of the eye had been evolved, and the subject of colour vision was still a theme of controversy. X-rays were produced by suddenly stopping electrons by flinging them at high speed against a target, whilst radio waves were produced by setting up electromagnetic oscillations and by using the two fundamental properties of the ether—elasticity and momentum—which Clark Maxwell proved were electric and magnetic respectively. The electric properties of the ether gave the necessary recoil or elastic recovery from the strained condition called electric charge, whilst the magnetic properties gave the momentum or impetus which enabled the discharged current to rush past the position of equilibrium and pile up a charge in the opposite direction, just like the momentum of a pendulum bob or the wire of a musical instrument. But if an attempt were made to generate light waves, those methods would not suffice. All that could be done at present was to throw the atoms of matter into the confused and irregular agitation called heat, or to get them to clash together, as they did in chemical combination, and to trust to the properties of the atoms themselves to emit waves of suitable size, as a bell did when struck by a hammer.

The generation of light was still a sort of blindfold method. A body was made hot and the result was awaited. But the discovery of the electron and investigations in connection with the structure of the atom were beginning to throw some light even on that process. Scientists knew, or they thought they knew, that an atom was a kind of solar system of electrons, in which they were revolving round a nucleus in a certain number of selected stable orbits, and there was reason to believe that they only radiated when they dropped from one orbit to another. The nature of the orbits and the laws of electron motion in the atom had been elucidated chiefly by the genius of Bohr, of Copenhagen, whose theory had been confirmed to a surprising extent and in astonishing detail by spectrum analyses. The province of chemistry had been invaded by physics, and the views as to the constitution of matter had been immensely enlarged and in some respects revolutionised.

The Radio Society was not concerned with small waves, nor with what went on in the interior of atoms, except that it utilised the electrons thrown off by hot atoms in the rectifying power of a valve. Apart from that, it dealt mainly, not with individual electrons, but with crowds of loose electrons which existed in a metal. When electrons were thrown into oscillation they were made to surge like a great crowd, and the elasticity of the ether was used to throw them back again when they had reached the end of their journey along a conductor, whilst the inertia of the ether in the shape of the magnetic field was made use of as the electrons rushed in a current through their positions of equilibrium, and piled themselves up at the other end of the conductor, to be thrown back again by elasticity once more.

The number of atoms in a piston-rod or fly-wheel had to be reckoned in billions or quadrillions, and the number which surged in a wireless aerial was of the same order. When radio waves were sent out it was not necessary to know exactly what the electrons were doing. It was not even exactly known why they were loose in a metal, whether they were surging about in it like a sort of atmosphere quite detached from the atoms, or whether they were quickly passed from hand to hand, as it were. For all practical purposes they were loose, but no final judgment had been pronounced as to the reason for this looseness. It was known that they were not quite free of the atoms because they jostled them, and they made the atoms shake as they passed by, so that a wire carrying a current could get red hot. Their energy in an ordinary conductor was therefore soon dissipated by being rubbed down into heat, although that kind of frictional dissipation did not seem to be essential.

If a metal were cooled down to a temperature near absolute zero, so that its atoms were still a quiet, the electrons would not be frozen into positions. They would be as mobile as they were before, but they would no longer jostle the atoms, the paths apparently being clear and open. A current started in such a metal did not lose its energy, for it was not rubbed down into heat, and it would continue by its own magnetic momentum for hours or days. But for practical purposes, it was not necessary to understand all that. Sufficient about conduction was

embodied in the law of Ohm. Electricity obeyed many of the laws of matter, which was not surprising, in view of the fact that matter was now known to be electrically composed.

Radiation, Sir Oliver said, was purely an etherial phenomenon—the pulsation, or vibration, or quiver or tremor in the ether. A tuning fork could be made to generate waves in air; in fact, any musical instrument could, but not in the ether. There was no mechanical connection between ether and matter. He had tried to carry ether along by spinning a steel disc at the highest permissible speed, but it refused to move, because there was no handle or grip. Mechanical motion and ether were independent. That was why the earth could spin for ever and why the planets could move without propulsion and without loss. The link between matter and ether was to be found in electricity and magnetism. An electric charge was concentrated on an electron—a constituent of an atom—but its field extended into the ether without limit. An electric charge was the connection between the two. When a charge moved it developed magnetism, the lines of magnetic force surrounding its path, and they, too, were in the ether. There was the other connection.

But neither an electric charge nor a magnetic field generated radiation. It was necessary to have the two superposed and at right angles to each other. The two gave radiation, travelling with the velocity of light and at right angles to both. That was called Poynting's Theorem—an outcome of Clerk Maxwell's work. An electric current was all magnetic, but if the speed of a moving charge was changed, if an electron were suddenly stopped, or if its motion were reversed, an electro-magnetic wave started out. Radiation was produced by changing the velocity of electrons, by accelerating them or retarding them, and in no other way. That theory was due to Sir Joseph Larmor, and it was developed in his book on ether and matter published in 1900.

Thermionic emission was another branch of the subject which was introduced mainly by Professor O. W. Richardson, although it was studied in the first place by Frederick Guthrie a long time ago. It had been admirably applied by Professor Fleming and others in the rectifying valves which had almost become domestic implements in many homes. When jostled, atoms not only emitted radiation, but they also emitted electrons. Any metal when clean emitted electrons when stimulated by the right kind of radiation, namely, radiation of the correct frequency.

Metals like gold and silver did not lose substance when exposed to light, which was perhaps just as well. They had to be exposed to X-rays before they responded. But light metals, like potassium and sodium, responded to ordinary light, and fortunately the same applied to something in the retina of the eye. Those substances flung away electrons at a characteristic speed when they felt luminous tremors, and it was to that strange and at present hardly accountable emission that vision was due. It was doubtful if the electric tremors affected the nerves directly, but it was probable that they stimulated something which was specially adapted to respond to the vibrations.

It would seem that the eye contained three different substances, each of which responded to its own particular frequency—its own particular length of waves—thus providing a means of detecting what the mind interprets as three different colours, red, green and violet, and of those three colour sensations, all colours were compounded. What was it, Sir Oliver asked, that stimulated the nerves at all? He believed that it was the electrons thrown off by the atoms with considerable violence. The energy with which the electron was thrown off depended upon the substance and the kind of light that could stimulate that substance, and it did not depend on the intensity of the light. No matter how feeble the light the response, was the same. The only difference was that feeble light could only stimulate a few atoms, whilst a strong light could stimulate a great many. But an exceedingly feeble light made some respond, and that was why the eye was so tremendously sensitive. The nerves had not got to appreciate the ether tremors directly. What the nerves felt was the shock of the ejected electron which struck them with a speed of some thousand miles per second.

That, Sir Oliver said, was the theory of vision which was in the process of being born, and which he felt sure contained the clue that had to be worked out by physicists and physiologists in combination. The eye was like a receiving instrument for detecting radio waves of short and definite length, and it was the first wireless receiving instrument used by man and by nearly all the animals. Vision was a photo-electric phenomenon. The growth of vegetation, he believed, was also a photo-electric phenomenon.

Thermionic emission was not an exact, economical and precise process. Heat was an irregular jostling. The atoms were thrown into vibration or they clashed together, and the result was that a hot body not only radiated, but it also threw away electrons, which did not seem to emerge with any characteristic velocity, but with every kind of velocity. It was more like the emission of atoms from the surface of a warm liquid or indeed from any liquid—the process known as evaporation. There appeared to be nothing electric about ordinary evaporation; it seemed like a mechanical process. The molecules were jostled and pitched out, whilst others entered and took their place. Evaporation and condensation were always going on.

When the atmosphere was thoroughly damp, evaporation did not cease; it was only balanced by equal condensation, and in that respect it was just like radiation. In a room of uniform temperature, the objects in it were in equilibrium, not because they had ceased to radiate, but because they received as much as they emitted. Radiation was going on from every piece of matter, until it was at absolute zero. It might emit more than it received, and in that case it would be cooling. On the other hand, it might receive more than it emitted, and it would then be getting warmer. But the interchange was continuous. So it was with radiation. The interchange between matter and ether was always going on. Every piece of matter emitted waves and also received them. If it emitted more than it received, it was getting cooler, whilst if it received more than it emitted, it was getting warmer, unless it made use of the received radiation for chemical and other purposes, so that the energy took some other form than that of heat. Besides the general etherial emission, there might be electric emission, too, and that occurred at a critical temperature, depending on the nature of the substance. Some substances emitted electrons easily before they were red hot; others had to be heated until they were white hot. Thermionic emission was therefore a kind of evaporation.

Referring to the connection between radiation and matter, Sir Oliver remarked that electric units were not all of one sign, but they were positive and negative. There were electrons and protons, which, when they came near together, tended to neutralise each other's outside influence, and that was why ordinary matter was electrically neutral. A little friction would disturb and separate them, but they would get together again as soon as they could. Whenever they approached each other, in falling together, they radiated, for their speed was obviously changing. The more violent the clash, the more vigorous the radiation. The question arose as to whether they ever actually clashed and annihilated each other. It was not known that they ever did; there seemed to be something that kept them apart, though they got very close together. Things on the earth seemed to be too staid and quiet to allow of an actual clash or anything like mutual extermination. But the operation was conceivable. It was known that some of the stars had a temperature which had to be reckoned in millions of degrees, and strange and violent things might be going on within them.

Some day it would perhaps be possible to make those things happen in a laboratory on a very small scale. Scientists could at least contemplate the process, and ask themselves what would happen if the units did clash. The answer was that the two would vanish in a puff of radiation and all that would persist would be their energy, which would no longer be localised in specks of matter, but would be travelling across space with the speed of light, and it would wholly belong to the ether. What was matter at one moment might become radiation at another. Dr. Jeans had estimated that the sun lost 4,000,000 tons of matter every second, that being the rate at which it radiated ether waves; 4,000,000 tons per second seemed a lot, but it made no perceptible difference to the sun, for it could go on expending itself at that rate for millions of centuries without apparent change.

Was there, Sir Oliver asked, any reciprocity about the process? Matter could turn itself into radiation, but could radiation turn itself into matter? He surmised that it could, but not under ordinary conditions. Waste radiation careering through space from all the innumerable objects and through innumerable millenniums, must, he thought, have some result, and he imagined it to be generating matter in the far depths of space. There was no ultimate dissipation of energy in the universe. The energy passed from matter to ether and back again. The energy of matter, was called kinetic, and that of the ether potential. Electrons and protons together constituted an atom of matter and atoms of matter constituted the whole of what we could see and handle. Was matter, then, a peculiarity or modification of the ether? That was exactly what he believed it to be, and the object of physics in the long run would be to explain all material phenomenon, first, in turns of electricity and magnetism, and then those in terms of ether.

There was reason to believe that the ether was under a gigantic pressure of 10^{29} dynes per sq. cm., and it was that pressure which held the electron together, in spite of the self-repulsion of its electric charge. Poincaré and Langevin had shown between them that that theory would account for the size of the electron and put it in equilibrium, and it was known that its electric field accounted for its apparent mass. What scientists did not at present understand was the remarkably greater mass of the proton. Why should that be 1840 times as heavy as the electron? What did that number 1840 or 1845 mean? Perhaps the electron was hollow, and that its charge just compensated the pressure and prevented collapse. The question then arose as to what had become of the material extracted? That had perhaps been jammed into the nucleus of the proton, and somehow it would account for the strange and at present empirical number 1845.

There was no time to justify or elaborate those suggestions; some of which were not ripe for elaboration, whilst others were. It was true that modern physics contained a great deal of inevitable speculation, but it was not rash and random speculation; it was all in the nature of working hypothesis based upon half-understood facts, and it clamoured to be tested by experiment and observation. Speculation was comparatively useless until it could be made definite, so that it could be tested, but if it suggested experiment, it was of value. Indeed, it could not be dispensed with, except when pursuing the regular course of orthodox dynamics, which had, everyone knew, in the hands of Newton and his great disciples, carried us very far, but which had now begun to show signs, not of weakness, but of lacunæ, gaps or interstices, which it was our business to fill.

POWER PLANT RECORDS.

ON Friday, January 23rd, Mr. R. H. Parsons delivered, before the Junior Institution of Engineers, a lecturette on the subject of "Power Plant Records."

Mr. Parsons began by saying that he was going to speak for twenty minutes only, and then leave the rest of the evening for discussion. In fact, in a little over that time, he had said enough to promote a discussion which served to throw into greater relief the value of his short remarks. He had most to say, of course, of what is known as the "Parsons' Line," which shows the relation between coal consumed and kilowatt-hours generated. He said that the study of this relation was the most direct way to economy, for once a standard had been fixed, any decrease or increase in efficiency was at once apparent. Half the value of the line was its immediate availability for reference with its lesson apparent on the face of it. Instrument records were usually too indirect in their objects to cultivate a conscientious interest in their meanings on the part of the station staff, but if a particularly low point off the line was obtained for a shift then the readings of the CO_2 and temperature recorders became of importance and interest. Mr. Parsons added that no records should be taken unless they were going to be the basis of some action. A point off the line showed when any action was necessary, unless the explanation was already known.

Mr. H. P. Gaze, in opening the discussion, said that there was no doubt of the value of the line for power station work, but he thought that for mixed plant the line might develop into a curve. Mr. Parsons would not agree. He argued that if the points went above the straight line when certain plant was working, the line should be left where it was as an indication that the particular plant should not be used more than absolutely necessary, and that the readings should be recognised as bad ones. Mr. Gaze also said that, in spite of Mr. Parsons' remarks about instruments, every instrument had its use and value, and if they were used with intelligence one could not know too much about the plant.

Mr. J. H. Gibson supported Mr. Parsons on the question of whether the line should be straight or curved in connection with plants of different consumption. He said also that Mr. Parsons' logic was very straight with regard to instruments. If the coal consumption was the best, then the CO_2 and flue gas temperature were the best possible. Indicating instruments were better than recording instruments, for an accumulation of paper and data often brought the readings into contempt.

HEAT TRANSMISSION THROUGH COATED PIPES.

IT having been said that a coating of Apexior would reduce the rate of heat transmission through a metal surface, J. Dampney and Co., Limited, requested the National Physical Laboratory to give them a report on the matter. The report lies before us, and reveals the very interesting fact that, under the conditions of the test, the rate of heat transmission through a tube painted with Apexior was considerably greater than that through the same tube unpainted.

The tests were made on two lengths of steel barrel about 50in. long by .665in. outside diameter. These test tubes were inserted one at a time in a larger tube, and in the space between the two a steady flow of water was maintained, whilst a supply of steam at 20 lb. pressure passed through the inner tube. The rate of heat transmission was measured by the help of thermometers placed at the inlet and outlet of the circulating water supply. If K be the heat transmitted per square foot per hour per degree difference of temperature between test pipe and water, then the results obtained may be summarised as follows:—

No. 1 Pipe ..	Bare	K = 307
No. 1 Pipe ..	Covered with Apexior	K = 414, an increase of 35 per cent.
No. 2 Pipe ..	Bare	K = 467 to 430
No. 2 Pipe ..	Covered with Apexior ..	K = 497, an increase of 16 per cent. on the lower value for the bare pipe.

It was observed that whilst the rate of heat transmission for the bare pipe began higher than for the painted pipe, it rapidly fell off, owing, probably, to corrosion. The number of coats of Apexior from one to four had little or no effect upon the rate of heat transmission. With regard to the improved transmission after coating, the report observes, "It does not seem probable that this can be accounted for entirely by the condition of the surface, while the conductivity of the wall cannot be altered by surface treatment. It may be suggested that the low value for the bare pipe may be due to the presence of gas bubbles due to the chemical action of oxidation in process, which may be almost entirely absent in the case of the tubes painted with a suitable preservative."

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

HIGH-PRESSURE CABLES.

SIR,—In the leader on this subject in your issue of yesterday you allude to Mr. Percy Dunsheath's statement, made two years ago, on the question of intersheaths that, if an intersheath cable were left without the ends connected to the transformer tappings the results would be quite as good as if the ends were connected.

I do not for a moment believe that Mr. Dunsheath holds the same view now.

With regard to your remarks as to dielectric loss, I would point out that if the cable were slightly enlarged so as to transmit 100,000 kilowatts, the percentage loss would be nearly halved, *i.e.*, it would not be greatly in excess of 0.9 per cent. of the power transmitted, say, 1.0 per cent.

I also hope to show at a future date how it is possible, if concentrated loads can be found at intervals along the line (such as at points where the line passes through large towns *en route*), that the inductive drop of the overhead line, to which you allude, may be largely compensated for.

If on a 240-mile transmission, such as contemplated in my paper, the inductive drop could be largely reduced (and, as I also hope, the hysteresis loss as well), rotary condensers might be correspondingly reduced in size and the general efficiency be so improved that a very clear case for alternating-current transmission would be established.

I thank you for your very reasonable criticisms of my proposals, some of which are, however, made under a slight misapprehension.

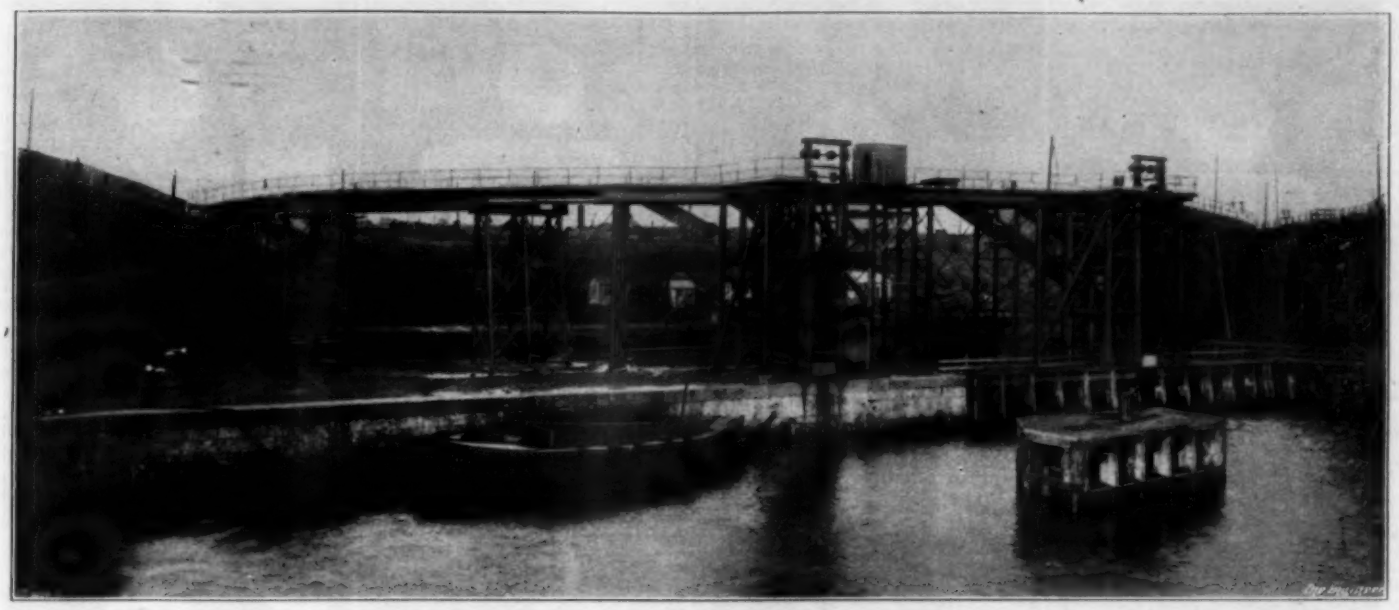
A. M. TAYLOR, Major, S.O.2.

Birmingham, January 24th.

ADDRESSING the United States Chambers of Commerce recently, President Coolidge said:—"They have government ownership abroad. It takes 23 men in Germany to move a ton of freight one mile, 24 men in Italy, 31 in Switzerland. In the United States it takes only 5 men. It is interesting to note also that reduced to terms of bread and butter, railroad employees in these countries show weekly earnings of only about one-third of those in this country. Measured by our experience, by efficiency of service, by rate of wages paid, we have everything to lose and nothing to gain by public ownership. It would be a most perilous undertaking, both to the welfare of business and the independence of the people." Mr. Coolidge might have added that Great Britain does better still. Only 1½ men are required.

NEW COAL STAITH ON THE TYNE AS SEEN FROM THE RIVER

MR. R. E. HINDMARSH, M. INST. C.E., NEWCASTLE-ON-TYNE, ENGINEER



New Coal Staith on the Tyne.

A NEW coaling staith, known as Staith No. 3A, has been constructed by the Tyne Improvement Commission on its dock estate. It is an addition to the five coaling staiths already in operation on the river frontage at Whitehill Point. The staith has been designed chiefly for the coaling of tugs, trawlers, and barges, and it will take wagons up to 20 tons capacity. It replaces an old timber staith on the same site, which could only take 4-ton box wagons, that had, when emptied, to be returned along the same line along which the full wagons ran on to the staith. Two coaling points have been provided which will deliver coal up to 12ft. above high water.

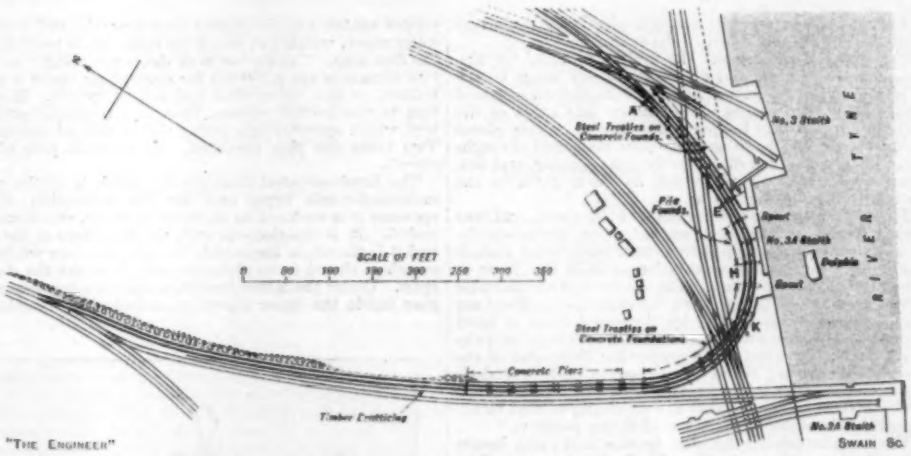
The staith, which is illustrated herewith and on page 134, is of the run-through type, and consists of a single line of rails on 6in. decking, with girders beneath supported by steel trestles and concrete piers. The wagons are brought along the full road to the hoppers by gravity, the "tip," or first run down, having a gradient of 1 in 23, down which the full wagons run, thence up a gradient of 1 in 70.7 to the coaling point. The latter point has been made about 2ft. 9in. lower than the top of the "tip," that being found by calculation to be the necessary level so that the wagons should have come very nearly at a standstill by the time they reached the hoppers. An experiment was made to check this, and we understand that the performance of the wagon agreed very closely with the calculation.

The full road is curved to 600ft. radius, while the empty road is curved to 131ft. radius. An experimental curve of 120ft. radius was laid down before the new staith was started, on another part of the dock estate, and some 20-ton London and North-Eastern Railway coal wagons were run over it successfully, there being no tendency to lock buffers. The gradient of the empty road was made 1 in 49 down, in view of the sharp radius, and it has proved satisfactory. Two hydraulic capstans have been installed. Their function is to start the wagons off down the empty road directly they are teemed, or occasionally to haul up wagons which have been braked too soon by the "bank-rider."

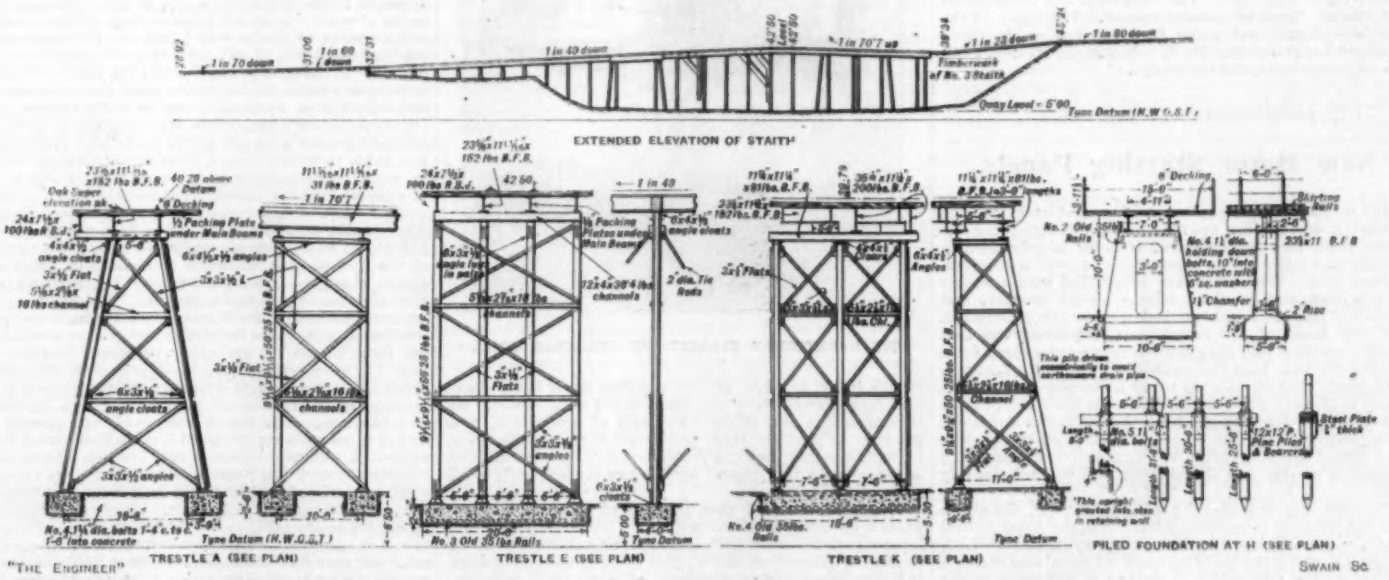
Broad flange steel beams, 24in. by 12in., generally 26ft. 9in. long, were employed for the main spans. In one span of 46ft. 6in. over railway lines, 40in. by 12in. broad flange beams were used, a deflection of ¾in. being noted under the test load of one 40-ton locomotive, and eight 20-ton loaded coal wagons. The "tip" itself is on an existing timber staith, and the new steel construction joins on to the old staith at the commencement of the up gradient to the hoppers. The trestles, fifteen in number, are built up of 9in. by 9in. broad flange beams and smaller British standard sections. Compound trestles have been built where railway lines run under the staith, partly because the trestles are not at right angles to the staith, and partly because they could not be tied together, on account of the head room required for rolling stock which passes underneath the new staith; 2in. diameter mild steel ties have been put in where possible.

The foundations for most of the trestles are concrete, reinforced in some cases with old 35 lb. rails. Three of the trestles are on piled foundations, at a point where the staith passes over a jetty. Most of the staith is built on made ground, and the concrete foundations are designed to give 1½ tons per square foot ground pressure under full load.

On the empty road, concrete piers replace the steel trestles for the last eight 26ft. spans. The piers are of mass concrete, the two legs being reinforced at the top by old



PLAN OF THE NEW STAITH SHOWING APPROACH LINES



ELEVATION OF STAITH, ARRANGEMENT OF TRESTLES, AND PILED FOUNDATIONS

"MIDGET" TYPE MOTOR STARTING PANELS

BROOKHIRST SWITCHGEAR, LIMITED, CHESTER, ENGINEERS

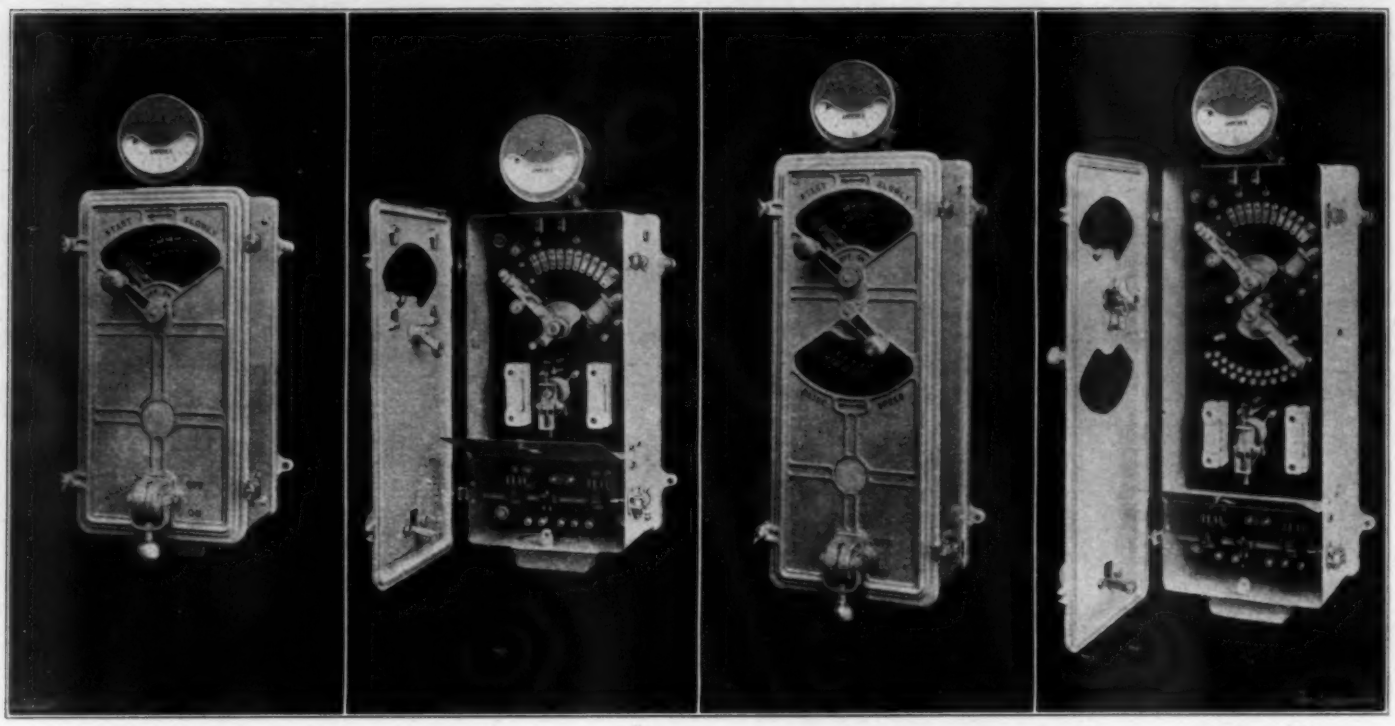


FIG. 1 FIG. 2 FIG. 3 FIG. 4

35 lb. rails. From the last concrete pier an embankment takes the empty road down to the existing railway.

The decking throughout the straith is 12in. by 6in. creosoted pitch pine, laid across the broad flange beams in 15ft. length. Additional 24in. by 7½in. British standard beams have been placed under the outside edges of the decking opposite the hoppers, and also at certain places on the straith; 90 lb. flange rails have been used throughout. They are spiked direct to the 6in. decking, and 2in. super elevation of the outer rail has been given to the curved portions of the straith.

The two coaling points are about 81ft. apart, and two timber structures have been erected to accommodate the shoot machinery, the tops of these structures being at deck level. Coal can be delivered either at H.W.O.S.T. or at about 10ft. to 12ft. above it. The outreach of the movable shoots is about 17ft. 6in. from the quay face. They are raised, lowered and housed by the usual form of hand gearing at deck level, and can be slewed by a rope from the ship's deck. The steel ropes supporting either end of the movable shoots are taken over separate pulleys at deck level, these pulleys having two weighted chains slung between them. The weights are so arranged that either end of the shoot is counterbalanced in any position.

The contractors for the steel trestles and main beams were Clayton, Son and Co., Limited, of Leeds. The Commissioners' staff carried out the remainder of the work, including the setting out, the construction of the reinforced concrete and piled foundations, the concrete piers, the decking, railways, hoppers, coal shoots, shoot gear, straith lighting, and the two timber structures housing and coal shoots. Dredging was also carried out and a dolphin altered to allow of trawlers coming alongside the straith with greater ease. The steel work has been coated with Wailes Doves bituminastic enamel. The whole of the work was carried out under the direction of the Commissioners' engineer, Mr. R. F. Hindmarsh, M. Inst. C.E., who was responsible for the design.

New Motor Starting Panels.

MOTOR starting panels, comprising a starter and the protective devices that are necessary for safeguarding the starter itself and the operator, are now largely used in factories and other places where motive power is required. Starters of this type, which are interlocked with a double pole, no-volt and overload release circuit breaker, and which are provided with an isolating switch interlocked with the doors of the switch case, represent the best modern practice, and they have been manufactured for a considerable time past by Brookhirst Switchgear, Limited, of Chester. For motors up to 10 horse-power, however, a fully protective starting panel is often too costly, for its price may not differ widely from that of the motor itself. Consequently, there has been a tendency on the part of small motor users to revert to the practice of employing a separate starter and double-pole switch, and possibly fuses.

To avoid this undesirable practice, however, the above firm has recently introduced some "Midget" type control panels, which are shown in the accompanying illustrations. The panels, which are made for constant speed and variable speed machines, give a certain amount of protection to the motor and to the operator, and this protection is suitable for the sizes of motors which these "Midget" panels are designed to control. The constant-speed panel is shown in Figs. 1 and 2, and the variable-speed panel in Figs. 3 and 4. In each case there is a face plate starter, with a no-volt release, and a spring return. There is no slow-motion action, for a plain lever handle is provided. The copper contents of the starter are renewable, and a carbon roller wiper, which can easily be replaced, is provided on the first step. The starter is of the non-inching type, but two terminals are provided for connecting up to a push-button, so that the no-volt coil can be opened. In addition to the no-volt release, there is a magnetic overload trip, which operates by opening the no-volt release circuit. Two fuses are also provided, one in each pole of the circuit.

The hand-operated double-pole switch is of the quick make-and-break type, and for the protection of the operator it is enclosed in an inner chamber, which may be sealed. It is interlocked with the main door of the case, and it is therefore impossible to open the door whilst the switch is closed or to close the switch whilst the door is open. Under the latter condition only the portion of the gear inside the inner chamber, namely, the double-pole

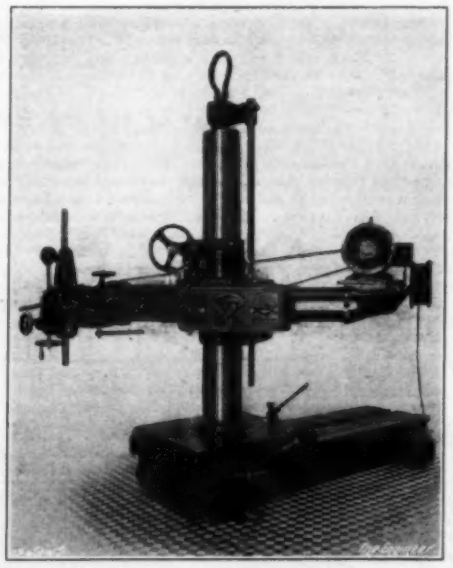


FIG. 5—"MIDGET" STARTER ON PORTABLE DRILL

switch itself, is alive, all the exposed parts being dead, and consequently they can be handled with safety. By careful design and efficient methods of production, it is possible to produce these panels at a reasonable price, notwithstanding that the protective devices are a distinct advance upon the general arrangements used with small motors.

The makers assert that the use of these "Midget" units is infinitely more desirable than the employment of a separate starter and switch and fuses, and that they should commend themselves, not only to users of electric motors, but to central station engineers, who are anxious to encourage the employment of good electrical control apparatus on their networks. The panels lend themselves very readily to incorporation in individual machines—as illustrated in Fig. 5—which shows a "Midget" control panel mounted on an Asquith portable drilling machine. The control panel shown in this particular illustration differs from the standard unit in that it is fitted with a reversing switch, but the illustration shows quite well how these new starters may be applied to machine tools.

South African Engineering Notes.

Rand Rockbursts Inquiry.

THE Union Government recently appointed a Commission, with the Chief Inspector of Mines at the head, to inquire into the causes of rockbursts which from time to time occur in the Rand gold mines' working and their possible avoidance. No time has been wasted in getting to work and it will certainly not be for lack of exhaustive investigation if the Commission fails to reach some very useful conclusions with regard to this troublesome aspect of mining operations. The Commission, which commenced its sittings within a week or so after being appointed, prepared a memorandum of points on which evidence is desired, and it appears to cover every phase of this apparently ever-present risk. The memorandum contains questions of such practical import as:—What are rockbursts? Are there different kinds? If so, in what mines or portions of mines, and under what conditions, are those kinds of bursts most numerous or serious? What are rockbursts due to? Are they due to direct pressure from the weight of superincumbent rock or bending of the strata, or to strains brought about by internal changes in the rock? Is the liability to rockbursts influenced by depth from surface, area of reef worked out, proximity to dykes or faults, direction of dip of those dykes or faults, or dip of reef? If the risk increases with depth is there any indication as to the rate at which the risk increases and the limiting depth of mining owing to danger from rockbursts? If the area of reef worked out affects the danger, is there any indication as to the proportion of worked-out area to pillar or remnant of reef at which danger arises? Do bursts occur where there are no dykes or faults? Is an underground area cut up by faults and dykes more or less liable to bursts than a similarly situated area almost or quite free from fault or dykes? Is there any evidence of subsidence of the surface over areas in which rockbursts occur? Is the risk greater where there are changes in dip or strike or where there are no such changes? Is the liability to rockbursts affected by composition or structure of the roof or rock, presence or absence of water in the strata, changes of rock temperature (ventilation), oxidation of minerals or occluded gases? "Has geological faulting come to rest on the Witwatersrand or have movements continued, either due to mining or not due to mining, on old fault planes?" are other pertinent questions contained in the memorandum, which goes on to deal with the structure of the hanging wall over an area subject to rockbursts and the relation of stoping width to the liability to rockbursts. "Is the risk of rockbursts greater when two or more reefs are worked?" is another line of inquiry suggested. Climatic changes and blasting effects are also considered, and the memorandum then goes on to ask what general principles should be followed in mining to control the frequency and seriousness of rockbursts. "Is it possible or advisable to avoid forming pillars or remnants of reef or other rock which may burst before they are stoped out," and such fundamental questions as "What is the most practical way to mine in order to reduce the number of such pillars or remnants to a minimum and should mining be so arranged as to aim at the blocks of ground being of any particular shape when reduced sufficiently to be considered remnants liable to burst?" are also propounded. "Can the liability to rockbursts or their violence be reduced and controlled by any method or quantity of support in workings, with special consideration of packs,

reef packing, pigstyes, current sand filling and sand filling of old stopes?" are questions suggested in this connection. "Is the risk greater with rapid continuous advance of stope face or with slow intermittent advance?" is another question of obvious significance on which information is invited.

The relation of rockbursts to shaft sinking and precautions for safeguarding winding shafts and shaft stations is also suggested for consideration, and the means of working out remnants is also the subject of a series of questions. It is explained that where practicable written statements should be accompanied by plans and sketches and by references indicating the particular rockbursts or other occurrences upon which the views expressed are based.

Mineral Production in South Africa

The total mineral production of the Union of South Africa for the ten months of 1924 ended October 31st amounted to £48,501,101. This amount is according to the statistics of the Department of Mines and Industries, which gives the value of the gold alone as £37,319,530. This latter amount, however, does not take into account the amount which the mines have to pay for realisation and exchange charges, which amounts to about a million and-a-quarter for the whole period. The other important items in the total mineral output are:—

	£
Silver	176,908
Osmiridium	68,509
Diamonds	6,812,346
Coal (10,403,695 tons)	3,192,074
Copper ore and concentrates	431,159
Tin concentrates and metallic	254,934
Other minerals	245,641

Making a grand total, including the gold, of £48,501,101. Of the less important minerals, lead has contributed £112,665 up to the end of October; asbestos, £95,433; corundum, £11,774; soda, £8342; magnesite, £3507; and arsenic, chrome ore, manganese, graphite, and iron pyrites furnish smaller sums.

Orders for Locomotive Boilers.

One records with regret that the larger portion of the contracts recently placed for ninety-four boilers required for various classes of saturated and superheated steam locomotives on the South African railways has been placed on the Continent of Europe. Orders for twenty-two of these boilers were placed with British engineers, the North British Locomotive Company, Glasgow, obtaining ten, Beyer, Peacock and Co., Manchester, nine, and Nasmyth, Wilson and Co., Manchester, three. On the Continent the Werkspoor Engine Works, Amsterdam, gets thirty-six boilers, Maffei, Munich, twenty-seven boilers, Krupps, Essen, seven, and Nicola-Romeo, Milan, two boilers.

LAUNCHES AND TRIAL TRIPS.

RUPERRA, steamer; built by Wm. Gray and Co., Limited, to the order of John Cory and Sons, Limited, Cardiff; dimensions, 409ft. by 53ft. by 27ft. 1¼in. Engines, triple-expansion, 26in., 42in. and 70in. by 48in. stroke, pressure 180 lb.; constructed by the builders; trial trip, January 13th.

ANTENOR, passenger and cargo liner; built by Palmer's Shipbuilding and Iron Company, Limited, to the order of Alfred Holt and Co. Engines, two sets of Parsons steam turbines; constructed by the builders; trial trip, January 15th.

CLYDEBANK, twin-screw motor vessel; built by Harland and Wolff, Limited, to the order of Andrew Weir and Co.; dimensions, 434ft. by 53ft. 9in. by 37ft.; to carry 5200 gross tonnage. Engines, two sets of six-cylinder motors; constructed by the builders; trial trip, January 22nd.

NEWFOUNDLAND, steamer; built by Vickers Limited, to the order of the Warren Line (Liverpool), Limited; dimensions, 423ft. by 55ft. 3in. by 34ft. 4in.; 6820 gross tonnage. Engines, one set of four-crank, inverted, vertical, direct-acting, surface condensing, quadruple-expansion, 31in., 43in., 62in. and 90in. by 57in. stroke, pressure 215 lb.; constructed by the builders; launch, January 24th.

HUMBER ARM, single-screw steamer; built by Sir W. G. Armstrong, Whitworth and Co., Limited, to the order of the Newfoundland Export and Shipping Company, Limited; dimensions, 439ft. by 56ft. by 39ft.; 8600 tons deadweight. Engines, triple-expansion, 28in., 46in. and 77in. by 51in. stroke, pressure 180 lb.; constructed by the builders; launch, January 26th.

NORDANGER, twin-screw motor tanker; built by the Netherland Shipbuilding Company; to the order of Westfal, Larsen and Co.; dimensions, 470ft. by 60ft. by 38ft. 6in.; to carry 12,750 tons deadweight. Engines, two Werkspoor Diesel motors constructed by the builders; launch, recently.

INSTITUTE OF MARINE ENGINEERS.—STUDENT GRADUATE EXAMINATION.—The following candidates have passed in mathematics and electrical engineering:—H. Caird, L. C. Crump, N. R. Gerrie, G. F. Kennedy, C. W. A. Maddock, C. Sykes.

FIGHTING FOGS AND SMOKE.—The heavy fogs which in recent times have become increasingly prevalent throughout the country are engaging the attention of the research departments of a number of manufacturing firms, particularly in industrial areas where smoke problems are often acute. With a view to counteracting as far as possible the physical and monetary loss caused by these visitations, the research is being conducted in two main directions. One branch deals with the discovery of more effective means of securing smoke abatement; the other with devising new appliances and apparatus for minimising the economic effects of fog in factories, business premises and the home, and for use in connection with transport by railway, road, sea and air. Some firms have the advantage of considerable experience in these or kindred matters, and it is believed that intensive study of the dual problem, such as is now taking place, will achieve a great advance on methods at present employed. It has been arranged that the practical results of this organised research and experiment will be demonstrated to the public at a special International Smoke Abatement Exhibition to be held in the autumn of next year at Bingley Hall, Birmingham, under the auspices of the Smoke Abatement League of Great Britain. This course is approved by prominent firms taking part in the movement, and a representative committee of experts is now in course of formation. It has also been decided that during the Exhibition, a series of important conferences covering every aspect of smoke abatement and remedial measures in periods of fog, shall take place. The headquarters of the Smoke Abatement League of Great Britain are at Manchester.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Inquiries More Numerous.

THE Midland iron and steel market remains featureless. The best that can be said is that inquiries are rather more numerous. Supplies of both iron and steel exceed demand, notwithstanding the fact that some ironworks have done little since Christmas, whilst others are running at much less than productive capacity. Values show no quotable change, though in one or two instances prices are said to have been shaded. Consumers are still buying on hand-to-mouth principles. Re-rollers continue to find fair business, but the general improvement from the rail orders which had been looked for is at the moment very moderate. Continental competition is still keen, but quotations continue to harden, and to-day in some cases they were fully 3s. per ton in advance of recent offers. The amount of business going to foreign works appears to be small.

Pig Iron.

There is no development with regard to pig iron. Continued abstention from buying is causing uneasiness among furnacemen, who did not avail themselves of the opportunity to sell forward that offered towards the close of last year. The higher prices quoted by some ovenmen for coke is causing increasing dissatisfaction. The steadiness of coke prices during the past few weeks has been mainly responsible for the maintenance of pig iron prices. With reducing exports there should be plenty of this fuel available, and it is difficult to see how ovenmen can make out a case for the increasing of prices. Coke makers should be careful to avoid doing anything likely to hinder the pig iron revival. In this district the furnaces operating appear to be well able to cope with the existing demand. Though there has been a good deal of talk about re-lighting idle furnaces, there has been no such expansion of business as to call for increased output. It is noted that at the beginning of the year there were six fewer furnaces in blast than a month earlier, the total for the kingdom as a whole being 167, against 173. Business is of a hand-to-mouth character, and it is stated that some few furnaces have, in order to secure business, lately shaded prices, Northampton foundry iron having been offered at £3 16s. and Derbyshire at £4 1s. The majority of the furnaces, it is certain, adhere firmly to recent prices and endeavour to get the maximum figure. The quotations generally prevailing on the market in Birmingham to-day—Thursday—were Northamptonshire forge, £3 11s. to £3 12s.; No. 3 foundry, £3 16s. to £3 17s.; Derbyshire forge, £3 17s.; No. 3 foundry, £4 2s. 6d. at furnaces. Forge iron is not much called for in the present quiet state of the Staffordshire iron trade.

Steel.

In the steel department, while the finished branches have very little work actually in sight, railway requirements, already belated, are relied upon to give a lead to more general buying. Negotiations for structural material have been opened, but actual contracting has been on a very limited scale up to now. Rail orders have formed a very small proportion of the new business given out by the leading lines, and several of the up-to-date mills are badly off for work. Shipbuilding requirements continue small. Steel makers quote £7 5s. to £7 10s. for billets, the market being slightly firmer with several firms asking £8 and upwards. There has been no renewal of the offers of supplies by Welsh firms at £7. Finished steel continues slightly easier. There are makers who, when pressed, are prepared to make concessions up to 2s. 6d. per ton. Boiler plates are wanted in larger quantity in connection with plant renewal and extensions. Numerous hardware trades call for larger tonnages. But such requirements are rather a side line. Values remain firm at £13 10s. delivered in the district. The steel trade has been assisted a little by increases in continental values. Billets are quoted from £6 2s. to £6 10s. delivered in Birmingham, and steel bars are rather dearer at £7 7s. 6d. delivered or £6 2s. 6d. f.o.b. Antwerp, a rise of about 3s. The continental makers require rather longer time for delivery, but a lot of steel is still coming in under old contracts.

Steel Scrap.

Steel scrap sells slowly, consumers demanding lower prices. There is still a large quantity of foreign material on offer, and the consumption of this material at the steel works is below the normal.

Staffordshire Iron Trade.

The Staffordshire finished iron trade continues generally quiet and unsatisfactory. Firms are making a stern fight to carry on, but it is feared that some further stoppages must take place unless the situation improves. The decision, announced in THE ENGINEER a fortnight ago, of Messrs. Adams, of Mars and Cleveland Ironworks, to close down has caused other ironmasters carefully to weigh the *pros.* and *cons.* of the present situation, and it is feared others may also abandon the struggle. There is no precise record of the South Staffordshire plants dismantled in the past thirty years, but they are estimated at between sixty and seventy. The effects of the slump are shown by the hastening of the process of scrapping during the last twelve months. About a hundred puddling furnaces have disappeared, together with a number of bar and sheet mills. Nothing is supplying the place of the plants which have been dismantled. One must not conclude that the South Staffordshire trade is in a state of dissolution. Though nothing is being done to replace the plants referred to above, the industrial equipment of the district has been strengthened in various directions since the war. It has been strengthened both for the production of steel and for the forging and rolling of the wrought iron which used to be the backbone of the South Staffordshire trade. It is reassuring to know that enterprise is not extinct in the district. As to the market position at the moment, the marked bar department is the only active line, makers of this high-class iron still having good order books. For Crown quality bars £12 15s. is the prevailing figure. Nut and bolt iron costs £11 15s. But against this Belgian No. 3 iron can be bought at prices ranging from £7 12s. 6d. The nut and bolt trade is rather busier, largely on account of the railway work given out; but stocks of bars for working up are still plentiful, rendering unnecessary any immediate buying of iron. Wrought iron gas tube strip commands £13 5s. Demand has slightly improved.

Galvanised Sheets.

Galvanised sheets are selling better. Twenty-four gauge corrugateds are firm at £17 5s. to £17 7s. 6d., with some firms asking higher figures. On the receipt of substantial Eastern business price cutting has practically ceased. Black sheets are an improving market, very good orders still coming from the builders of motor cars, motor cycles, &c. Larger quantities of this material are consumed by Birmingham stampers and a number of hardware trades.

Black Country Industries.

Several of the industries in the Black Country, notably the nut, bolt, rivet, screw and stud trades, have benefited by the schemes which are being carried out by the various railway companies. Some firms have booked orders which will provide employment throughout the year and enable them to augment the number of employees.

Edge Tools.

Business in the edge tool industry in the Midlands is moderately good, though it has dropped off somewhat during the last fortnight, but firms are booked up for weeks ahead, though they could handle a lot more orders than they are getting. The demand for many classes of plantation tools does not declare itself before the spring, and the same applies to gardening tools for the home market. The export demand remains good and prospects are encouraging, though Germany is increasing her efforts to secure, amongst others, the Indian market.

Contracts for the Midlands.

Additional important contracts have recently been placed with Midland firms, amongst them being the supply of motor generators and switchgear for the Swansea Docks, the General Electric Company, Witton, Birmingham; supply of turntables for Cardiff Docks, the Horsehay Company, Limited, Horsehay, Salop; construction of additional cattle lairage accommodation at Fishguard, W. T. Nicholls, Limited, Gloucester.

Strike Called Off.

As I anticipated in my letter last week, the threatened strike of 20,000 Derbyshire miners has been called off. At a special meeting of the Derbyshire Miners' Association Council on Saturday it was decided to withdraw the notices to cease work on behalf of the men engaged in the soft coal pits, respecting the restoration of 7½ per cent. wages reduction. The Council considered the moment inopportune for ceasing work. It is added that the Association will press the claim "when an opportunity presents itself."

Dearer Coke.

The expected easing of coke prices has not taken place. On the contrary, new quotations show a rise of 2s. to 3s. per ton for Yorkshire and South Wales fuel. The sellers are showing some firmness, preferring either to stock their fuel or shut down their ovens rather than sell at recent prices. Midland blast-furnacemen are much perturbed. The dearer coke will add about 5s. to the cost of pig iron production.

Unemployment in the Midlands.

Again this week there is recorded a satisfactory decrease in the number of unemployed in the Midlands, the total figure of 154,647 being 2659 lower than the previous week, and 11,138 less than a fortnight ago. The figures for the present period are made up as follows:—Men, 104,476; boys, 3497; women, 41,831; girls, 4843. Though slight increases are recorded at Cradley Heath, Derby, Leicester, Nottingham, Peterborough, and Walsall, the decline in other areas has been much more pronounced.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

General Outlook.

THE general condition of the iron and metal markets has been decidedly dull and quiet, and hopes of a revival are now postponed until the spring has advanced further. The expectation that the influence of the railway expenditure would have been felt here by this time has been disappointed, but in the end this must affect the market to a certain extent. So far as general buying of iron and steel is concerned, there seems to be a disposition to hold orders back. At any rate, there is little new buying in this district, although some pessimists affirm that orders are not being held back, but are simply non-existent. The weakness of the market may, however, be an inducement to postpone any buying that might be done, although it is not easy to see how, in the iron and steel trades, it will be possible to reduce prices to any serious extent.

Metals.

The sharp set-back in all departments of the non-ferrous metal markets which occurred last week has no doubt effected some good in the way of shaking out weaker

speculators. These timid people always flock into a market which is moving upward, and no doubt a periodical clearance is necessary, even if it be painful. There is really nothing in the trade situation which justifies lower prices in the metal market, and there would now seem to be a probability of a return to the conditions prevalent three weeks ago. One does not, of course, look for any spectacular change in these markets, but prospects of consumption are slowly improving. It cannot be denied that the fall in copper and tin prices has checked the tendency on the part of consumers here to buy for stock and to hold larger quantities, and no doubt a period of slowly improving prices will be necessary before this movement sets in again. There are, however, indications that the consumption of the non-ferrous metals in this district is gradually increasing, and the effect of this ought to be felt in the course of the spring months. So far as copper is concerned, the position in the United States seems to be fairly safe. It is true that consumers there have, to a large extent, satisfied their needs for the present, but the large producers are also well sold and do not require to obtain fresh business for the next month or so. There was a trifling reduction in the official price for sheet copper, as a result of the set-back, but no change was made in tubes. The home prices for these products are still held at prices much higher than can be obtained for export, and to this extent the home consumer is suffering. In the market for tin there have again been wide fluctuations. The total extent of the drop from the highest point was about £25 per ton, and as there is no really definite change for the worse in the general situation, this seems a little extravagant. The process of recovery has begun, and there are many people here who believe that the former prices will be reached again. The market for lead is now recovering from the scare, although the prices occurring in the middle of this month may not be seen again. Spelter has not suffered very much beyond a sympathetic movement. The general conditions are practically unchanged.

Pig Iron.

The demand here for foundry pig iron is confined mainly to small lots; but, of course, there are yet a good many contracts running which were made during the six weeks which followed after the change of Government, and deliveries against these provide a good deal of work for the makers. Hence there is no immediate pressure to sell, and the price for Derbyshire iron is fairly firmly held at 90s. per ton delivered in this district. The lack of fresh business, however, gives the market rather a dull appearance, and if it continues some weakness in price is possible later on. It is said that in some parts of Lancashire the foundry industry is better; and that one or two of the big textile machinery firms are now working full time. Assuming that these reports are accurate, it is, however, the case that many of the smaller ironfounders are short of work, and prices for ordinary castings are still cut very fine. The comparatively small demand for foundry scrap—*i.e.*, broken cast iron—is a fairly good indication of lassitude at the foundries. There is a little Northamptonshire iron to be had here at about 88s. 6d. to 89s. per ton delivered, but otherwise the Derbyshire brands at 90s. are the cheapest pig iron in the district. Scotch iron is still quoted at 107s. 6d. delivered, and is, as a rule, too dear for ordinary use; but it must be remembered that the dearness is caused by the excessive carriage and not by the cost of Scotch iron at the furnaces. The difference between Scotch and Derbyshire at their respective furnaces is only 7s. 6d. per ton. East Coast hematite iron remains quiet and dull and is a comparatively cheap iron for those founders who can use it.

Steel.

The market here for manufactured steel remains in a very lifeless condition. The nominal prices are held steadily at £9 per ton for joists and angles, £9 15s. for plates and flat bar rail, and £10 to £10 5s. for round bar steel. How far these figures might be shaded for prompt and favourable specifications it is difficult to say. Sellers are rather reticent on this point, and it is necessary to have a good order in hand and be ready to place it before the complacency of the manufacturer can be tested properly. Lancashire malleable iron seems to get more difficult to sell as time goes on, and although these things are kept fairly quiet, it is probable that the consumption of the higher grades of Belgian iron is increasing in the country.

Scrap.

There is practically no change in the situation as regards scrap materials. Dealers usually quote 85s. delivered for good broken machinery scrap, and 87s. 6d. to 90s. delivered for heavy wrought scrap. The position of steel scrap is uncertain, but it is no worse than it was last week.

Manchester Ship Canal.

In spite of the national strikes and labour troubles which took place in the early part of last summer, the Manchester Ship Canal can claim to have had a very satisfactory year. The aggregate receipts for the twelve months were £1,463,656, or about £79,000 more than last year, which in turn showed an increase of £52,000 over 1922.

How Trade is Handicapped.

Speaking at the annual meeting of the shareholders of the District Bank in Manchester a few days ago, Sir Christopher Needham, the chairman, made some interesting comments on the cost of production of iron and steel in this country. He said that the Board of Trade index figures for November showed that British steel prices were only 36 per cent. above those of 1913, while coal—of which 3 or 4 tons are required to produce 1 ton of steel—was 60 per cent. above and general commodities 70 per cent. above. Many items which went to make up the cost of production, such as railway rates, which are on the average at least 50 per cent. over 1913, taxation and local rates were completely outside the control of the iron and steel trades, and until they were reduced it did not seem possible to bring down the prices of their products materially. A recent calculation showed that the increases in rates and taxes, together with National insurance, represented for an important steel works an advance of over 282 per cent. as compared with the year 1913. During the last few weeks there had been an increase in prices of steel products on the Continent. The operation of the Dawes plan in Germany, coupled with the stabilisation of German currency, was already increasing German costs, and it was thought that those costs must increase still more. Until French and Belgian currencies become more stable there would necessarily be uncertainty in regard to their competition.

BARROW-IN-FURNESS.

Hematite.

There is a slightly better tone in the hematite pig iron market, both the inquiries and the demand being a little better. There is nothing very startling in the way business is shaping, but, on the other hand, the feeling of optimism is beginning to be more generally felt. The home demand is pretty steady, and customers are more inclined to look ahead than they have been lately. Scotland and the Midlands are the biggest customers, and there is some chance of their business improving. The continental buyers are few and the tonnage is not heavy. America offers possibilities, and a few orders are held in the district, but it is impossible to say, at the moment, whether the trade will improve or fall away. With the steel departments better placed for orders, which will lead to a regular consumption of iron, the output is certain to be maintained if not improved in the early future.

Iron Ore.

The iron ore trade continues to be steady, but there is not a demand for much outside the district. Local demands are fair, and there is a possibility of a further improvement as the local iron trade develops. Spanish and North African ores are in steady demand, and there are regular imports at Barrow and other ports on the West Coast.

Steel.

The steel trade, as far as the rail mills are concerned, is a little better, and the Workington steel rail mills will be kept going with present orders into March. The Barrow rail mills which have, comparatively speaking, had a fair run, are likely to be kept going for a month or two yet with orders which have been placed with them. Foundries are experiencing a fair amount of business and are fairly well employed. The hoop and small section mills have orders which will keep them going at present.

An Alarming Collapse.

On Monday night there was an alarming occurrence at the United Steel Company's works at Workington. A furnace, roughly measuring 60ft. high with a diameter of 30ft., suddenly collapsed. The whole structure fell on to the pig beds and created great consternation. The tremendous flare could be seen in the sky for many miles around. Fortunately no one was killed, but the blast-furnace manager and a few other hands were burned and otherwise injured. No reason has yet been given for the collapse.

SHEFFIELD.

(From our own Correspondent.)

Decline in Crude Steel Trade.

THERE is nothing of a cheerful character to report with regard to the trade in the raw materials for steel making or in crude or semi-manufactured steel. On the contrary, so far as pig iron, billets and the cheaper rolled material are concerned, January has shown a decline as compared with December. The slight easing of prices in the pig iron market has put an end to speculative buying. A policy of extreme caution is being pursued on all hands, and consumers, doubtful as to the trend of prices in the immediate future, are limiting their purchases to such quantities as will cover immediate requirements only. Orders for basic billets of low grade are so scarce that furnaces in the district are not working up to half their capacity.

Improvement in Acid Steel.

On the other hand, the acid side of the steel trade is able to give a better account of itself. This material is largely used in the production of railway supplies, and the extensive orders for axles, tires, springs, and buffers which have been placed recently have resulted in an increased demand for the products of the furnaces. At the works of the Parkgate Iron and Steel Company a large basic furnace has just been converted for the production of acid ingots and billets, and the establishment has now altogether six large furnaces working. The local firms engaged on railway work have on hand good orders from the British companies, and it is anticipated that the present level of business will be kept up for the greater part of the year. The amount of business from overseas continues disappointingly small, but it is believed that before many months are passed more orders from India and South America will be received. There is not much being done at present with regard to wagons for private owners, but here again contracts are likely to be given out later in the year. The heavy side of the steel trade is interested in the report that the Admiralty intends to press for the construction of four cruisers during the year. If the scheme is approved it will no doubt result in Sheffield's receiving orders for light armour and guns, forgings and castings.

The Lighter Branches.

Warship construction also means an increased call for tool steel and tools, so that these important branches of the Sheffield lighter trades will also benefit by the proposed building. At present those trades report conditions of a very mixed character. The demand for crucible steel, and especially for high-speed steel for engineering tools, grows very slowly. Some of the tool factories are able to work almost full time, but in other cases there has been a falling off since the beginning of the year. The saw department, which enjoyed great activity during the bigger part of last year, is now very quiet, while a good deal more work in the twist drill and cutter shops would be welcomed. Makers of farm and garden tools are looking forward to a good year, as they have much less foreign competition to meet than formerly, and they have been able to ease their prices somewhat. Many foreign markets prefer Sheffield-made garden shears to any others, and this applies even to the United States, in spite of the heavy import duties. In the sheep shear trade, which was not well employed last year, things are not improving. The principal market is Australia, and the orders which that country has sent forward have for a long time been below the average.

Cutlery and Plate.

So far, the distributors of cutlery and plate in this country have not bought much during the present year. Travellers report that they are showing extreme caution in placing orders, and that counter sales since Christmas have been very poor. In the cheaper classes of stainless knives and cased goods, however, considerable activity is maintained, and the prospects generally suggest that the volume of trade this year will be equal to last year's. A promise of better business with Ireland is reported. The overseas demand generally is moderately good, especially from Australia, which is the principal colonial market, and one in which a good quality of ware is favoured.

Threat to Trade with France.

Sheffield at present carries on a pretty good trade with France in steel and tools, but the proposed new French tariffs are so severe that much alarm is felt in the city. It is declared that, if the proposals become law, the result will be the stopping of practically all exports from this city to France, with heavy loss to our manufacturers and serious inconvenience to French users. The Sheffield steel manufacturers are circularising their French customers in an effort to arouse public opinion against the increases. They point out that the proposed duties are so much higher than the present rates "that Sheffield firms cannot at present see their way to quote for delivery duty paid, for the reason that it is quite impossible to calculate the expense of delivery." As illustrating the seriousness of the situation, the following proposed increases may be quoted:—High-speed steel from 95f. to 200f.; special steels from 34f. to 50f.; hand saws from 100f. to 300f.

The Doncaster Coalfield.

Continued progress is reported in the development of the coalfield in the Doncaster area. At the new Thorne Colliery, where the Barnsley seam was reached last summer in No. 1 shaft, it is expected that the same bed will be reached in No. 2 shaft during the present year. In the meantime headings are being driven from No. 1 shaft to No. 2, and the coal is reported to be of excellent quality and workable. Preparations are being made for the erection of a colliery village of 2000 houses, to accommodate 10,000 people, at Thorne Moorends, and also for the beginning of a sewerage scheme.

Elimination of the Pit Pony.

A year or so ago great interest was excited among all connected with colliery engineering by the offer of Mr. Charles Markham, chairman of the Staveley Coal and Iron Company, Limited, of a prize of £1000 for a safe and efficient type of electric storage battery locomotive for haulage work underground. The outcome of this offer is likely to be seen during the next month or two, when tests of new types of locomotives will be carried out on ground near the Brodsworth Colliery. Should a suitable locomotive be discovered its use in the pits will mean the elimination of the pit pony.

Colliery Electrical Line.

Another item of colliery interest relates to the electrical linking up of the various pits in the Markham group near Doncaster. A great part of this work has already been carried out, and now a start is to be made on a new line of cable, 7 miles long, to connect the Yorkshire Main Colliery at Edlington with Hickleton Main. When this is finished Doncaster will be completely encircled by an electric power line. Each of the pits is provided with its own power station, and the value of the electrical circle lies in the fact that, in case of a breakdown at any one pit, a stoppage can be avoided by switching on to the line. It is intended, at a later date, to carry the new line on to Frickley, to connect up with the Grimethorpe and Brierley pits. This group is now engaged on the erection of a central power station for transmitting at a pressure of 20,000 volts. The present transmission from the Markham group is at 10,000 volts, but when the Frickley group is connected up transformers will be installed.

Pit Head Baths in Sheffield.

An installation of pit head baths, the first in Sheffield, is now nearly completed at the Nunnery Colliery, and is expected to be in operation shortly. The bathing room is a substantial brick building, measuring 70ft. by 30ft., which provides accommodation designed to meet the needs of 250 men per hour. Hot and cold water are provided, the hot being turned on by pressure on a footboard, and thirty-two showers are designed so that a man can get a satisfactory wash in about seven minutes. Arrangements are made for the men to leave their pit clothes at the baths and to go to and from home in cleaner attire. The working clothes will be hung on pegs and hoisted to the ceiling and will be thoroughly dried, by means of ventilation, between the shifts.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Iron Trade.

THE feature of the Cleveland pig iron trade this week has been a renewal of inquiries from the United States for supplies, and if some of these developed into orders it might give a welcome fillip to the trade, although there seems little prospect of getting iron across to America except for consumption on the Atlantic seaboard. Cleveland's chief trouble, however, is that she is still being undersold in continental markets, and as a consequence the export trade has fallen to almost negligible proportions. Whilst this obtains Cleveland is handicapped, for the home demand is scarcely sufficient to absorb the whole of the local output. Thus, although already heavily sold, makers are anxious for orders, and are cutting prices in order to get them. As a result Cleveland iron is now the cheapest in the country, and good sales have been made to Scotland, but more business is needed yet to stiffen the market. No. 3 G.M.B. Cleveland pig iron is now quoted at 79s. per ton, the lowest price touched for exactly nine years. Other qualities are in the usual ratio, No. 1 becoming 84s., No. 4 foundry 78s., and No. 4 forge 77s.

Hematite Pig Iron.

There is a fair inquiry for East Coast hematite pig iron, sales to home consumers being supplemented by a little foreign business. The production, however, is in excess of requirements, and makers are still keen for orders. Mixed numbers are quoted at 87s. per ton, with No. 1 at 6d. per ton premium, but a substantial order might be placed at less than those figures.

Ironmaking Materials.

The foreign ore trade is without any special feature. Very little new business is being placed, and 22s. 6d. is purely a nominal figure for best Rubio c.i.f. Tees. For good Durham furnace coke 24s. 6d. per ton delivered at the works is now a sellers' price, and possibly business could be placed at 24s.

Manufactured Iron and Steel.

Considerable continental competition has still to be met with by producers of finished iron and steel, though price cutting by firms abroad is not so keen as it has been. Foreign semi-finished material is, however, still offered freely in the home markets at figures much below rates named for local products. Business in finished steel shows some improvement, and production is being fairly well maintained. Black sheets are in little request, but both with India and the Continent good business has been done in galvanised sheets. Prices generally are steady and unchanged.

The Coal Trade.

The position in all branches of the Northern coal trade is exceptionally disappointing, and new transactions are almost negligible. Here and there a few coalowners are well booked and supplied with orders, and have tonnage supplies on hand, but many others are hard pressed to keep the pits going, even at the present moderate output, while beyond this week the outlook is discouraging. Despite every effort of fitters, supported by merchant exporters, business is difficult to find, and the question of trade for the next few weeks is doubtful. Merchants who have returned from the Continent have brought back with them no new business worth speaking of, and they declare there are large stocks of coal in Germany and France, so that the demand for the present is fully supplied. A good deal of interest has been centred upon the preliminaries with regard to the national coal agreement. It has been noted with satisfaction that the opening stages resulted in the matter being referred to the mining associations of the country previous to the national conference to be held in London in February. Last year the agreement was fixed almost at the last moment, but this year some time is to be allowed for serious consideration of all the aspects of the question. There is a great deal in the present agreement which is of immense value which the men are not likely to allow to be abandoned. In Northumberland and Durham there is no desire for any stoppage, as in view of the present poor export trade it would mean that America again would cross the Atlantic and secure our customers, as was the case in 1921. While coal holders are still asking recent prices for all qualities, the few orders available are snapped up at fractional discounts. Best Northumberland steams are quoted at 18s. 6d. per ton, and best Durham gas at 21s. 6d., but in each case concessions might be secured by the placing of good business. Durham ordinary bunkers are a quiet trade at 18s. Demand for all descriptions of coke remains dull, and stocks are ample for all requirements. Gas coke is quoted at 23s. to 25s.; patent oven coke, 23s. to 25s.; beehive, 30s.

SCOTLAND.

(From our own Correspondent.)

Markets Unchanged.

CONDITIONS in the steel, iron and coal markets remain unchanged on the whole. A slightly better tone is apparent, however, in some directions, and some hopes are entertained that a distinct improvement will be noticeable before the end of March.

Pig Iron.

A moderate amount of buying in pig iron is reported, but the total turnover is small in comparison with normal times. The bulk of the business passing is for home delivery, but a few export inquiries have been received of late. Prices are nominally unchanged, but, owing to the fact that stocks in makers' yards are not decreasing, easier quotations might be obtainable for a good order.

Steel and Iron.

The steel market is a shade more hopeful. Shipbuilding demands are still disappointing, but the requests from structural engineers, locomotive works and other sources have improved. The percentage of the plants in operation is small, however, and there is a big leeway to make good. No change in steel sheets is mentioned, the light gauges being still busy chiefly on export account, while heavy gauges move slowly, but with promise of early expansion. Bar ironmakers have secured some business in connection with recent railway contracts, but orders generally are slow to mature. The re-rolled steel section of the bar iron trade is a shade busier. The demand for scrap material keeps within small limits.

Coal.

The Scottish coal trade is extremely unsatisfactory. The tone is very weak generally, and it seems certain that any further drop in prices will result in the closing down of some pits, as in numerous instances serious losses are incurred through restricted outputs and high oncosts. Holders are being compelled to take up balances of contracts fixed last year, while in some cases collieries are selling against them at considerably cheaper prices. Apart from Lanarkshire prime splints, and in a lesser degree Lothian steams, all qualities of fuel are weak and pressed for sale, especially in the case of washed materials. The drop in foreign orders for prompt delivery is very keenly felt, while exporters find great difficulty in negotiating forward transactions, even when inclined to discount current prices. Aggregate shipments for the past week amounted to 225,009 tons, against 224,006 tons in the preceding week and 187,394 tons in the same week last year. The home demand for fuel of all descriptions is far below normal for the season of the year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Outlook.

THE outlook in the steam coal trade does not appear to be any too bright at the moment. The conditions are very quiet and values are only just about maintained, while business ahead is not helped by the threats of trouble in the future regarding the new agreement. The speeches of the secretary of the Miners' Federation delivered recently, are calculated to do considerable harm, more especially as the present agreement does not expire until the end of June, and one month's notice is required to terminate it. The statement of Mr. Evan Williams, the president of the Mining Association of Great Britain, deprecating alarmist outbursts is welcomed in trade circles, as they tend to cause a feeling of uncertainty on the part of foreign buyers. It is possible that foreign consumers are not so nervous about supplies being cut off from this district as they have been in the past, for the reason that they can secure continental and American coals on such good terms. One suggestion which has been put forward, and that from the labour side, which meets with very considerable approval from commercial circles, is that the new agreement should be operative for a period of five years as against one year at present. This would certainly be a great advantage to trade, as it would impart a feeling of security and stability, whereas under existing conditions no sooner is an agreement come to than the time has to be looked forward to when discussions are renewed respecting its revision with, of course, unsettling effects.

Welsh Coal Too Dear.

The position in the steam coal trade was dealt with at a meeting of the Cardiff Chamber of Commerce on Monday, when the chairman, Mr. C. L. Clay, expressed the view that coal was too dear. He said that the year 1924 showed a great falling off compared with 1923, and he thought that this year would be worse still. In France they were told that their coal was hopelessly too dear. They were, as a matter of fact, shut out by the increasing output of French coal, reparation coal from Germany and German free coal. There was also Belgian, Dutch and American coal to compete with, and if the Frenchman wanted to buy British coal he was more likely to buy D. C. B. large from the North-East Coast than anything South Wales could offer. The only way to bring down c.i.f. prices was by an heroic effort by all sections of labour, and with the help of the Great Western Railway Company. It was not fair to ask one section of labour alone to sacrifice its leisure and its earnings for the common good; but perhaps if all sections were approached they would be willing to meet the situation. They should realise at the same time that the converse was true, and that if labour, by insisting on its nominal wage and its leisure, was going to strangle trade the cost of living would go up and real wages would drop.

Anthracite Dispute Settled.

It was announced last week at a meeting of the joint standing disputes committee of the South Wales Coal Board, that Mr. Robert Gibb, chairman of the South Wales Coalowners' Association, and Mr. Enoch Morrell, president of the South Wales Miners' Federation, acting on behalf of the workmen, had signed an agreement embodying a new schedule of rates which would affect a number of collieries in the anthracite area, and that these rates would be retrospective to Wednesday, December 10th last. This agreement concerns the rates of wages of boys employed on the surface in the anthracite district, and the dispute at one time threatened serious developments, as it was feared a stoppage of work would take place.

Tin-plate Industry.

A brief reference was made last week to the fact that tin-plate manufacturers had decided to share orders and regulate output. This is a scheme that will be watched with a good deal of interest not only by those in the trade but in other industries. So far as production is concerned, the scheme put into operation is to restrict output by closing down five shifts per mill per week over a period to terminate at the end of February. With regard to the developments foreshadowed in the manufacture of tin-plates, it is reported that the new type of tin-plate continuous rolling mill, for which Mr. Cound is responsible and from which great results are expected in the matter of production and cost, is to be experimented with by a limited liability company, which is in process of formation. It is stated that no time is to be lost in putting the invention to a practical test on a thoroughly adequate scale.

Current Business.

The tone of the steam coal market continues to be on the quiet side. Some of the leading undertakings are quite well off both for orders and ready tonnage, but the case is different with many others. The tonnage position is not quite so good this week, and so far, at the docks at which the bulk of the steam coals are shipped, the number of steamers waiting to load just about balances the number of berths available. It will, therefore, be seen that there is no undue pressure, and the tendency is for stocks of coal to accumulate with those firms who have no tonnage actually under the tip. The consequence is that there is no real strength in the market, but, on the contrary, a certain amount of irregularity in prices for prompt loading. This applies more to large coals, as with production of large somewhat interfered with, the supply of smalls is reduced and they are quite firm, especially the better qualities. The situation in the anthracite trade does not show any improvement, and shipments are less active.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

IT is announced that Sir W. G. Armstrong, Whitworth and Co., Limited, have acquired from the receiver for the Boving Engineering Company, Limited, the goodwill, plans, patterns, &c., of the Boving pump.

MR. A. J. THORNELOE, A.M.I.M.E., informs us that he has resigned his position of sales manager to the G. Cohen and Armstrong Disposal Corporation, and requests that communications should be addressed to him at his private address, Northbank, Kellfield-avenue, Lowfell, Gateshead-on-Tyne.

WE are asked to state that the *Journal of Scientific Instruments*, a monthly publication dealing with their principles, construction and use, produced by the Institute of Physics with the co-operation of the National Physical Laboratory and hitherto published by the Institute, will in future be published by the Cambridge University Press on behalf of the Institute.

CONTRACTS.

THE LEEDS FORGE COMPANY, Limited, of Leeds, has recently received orders for steel vestibule brake coaches from the London, Midland and Scottish Railway, and orders for 531 goods and hopper ballast wagons from Indian and African railways.

FOR the extension of the Bedford Corporation Electricity Works, the borough electrical engineer of Bedford (Mr. R. W. L. Phillips) has specified the use of the rapid hardening cement "Ferrocrete." The same material is to be employed in carrying out an extension of the Neschel's power station, Birmingham.

CALENDARS, DIARIES, &c.

SOCIETA ANONIMA ANSALDO, VIA CESAREA, 15, Genova.—Wall calendar with monthly turnover cards.

INTERNATIONAL CONSTRUCTION COMPANY, Limited, 56, Kingsway, W.C. 2.—Wall calendar with monthly tear-off sheets.

MARSHALL, SONS AND CO., Limited, Gainsborough.—Wall calendar with monthly tear-off sheets.

CATALOGUES.

W. J. FURSE AND CO., Limited, Traffic-street, Nottingham.—A lightning conductor list.

HERBERT MORRIS, Limited, Loughborough.—Folder illustrating the uses of the Morris overhead runway.

DELCO-REMY AND HYATT, Limited, 56, Victoria-street, S.W. 1.—Leaflet A.U. 35 on front wheel hub mountings.

KENNICOTT WATER SOFTENER COMPANY, Wolverhampton.—Catalogue of the Kennicott products entitled "Water Purification."

MANLOVE, ALLIOTT AND CO., Limited, Nottingham.—Leaflet calendar for January illustrating the Manlove multi-jet washing machine.

W. AND T. AVERY, Limited, Soho Foundry, Birmingham.—Catalogue No. 4000, illustrating and describing all types of Avery weighing machines.

BOVING AND COMPANY, Limited, 56, Kingsway, W.C. 2.—Two booklets on water turbines, hydraulic governors and pipe lines installed by Boving and Co., Limited, one in English the other in Spanish.

THE IRON AND STEEL INSTITUTE.—The annual meeting of the Iron and Steel Institute will take place on Thursday and Friday, May 7th and 8th, at the House of the Institution of Civil Engineers, Great George-street, Lindon, S.W. 1. The annual dinner will be held on the evening of Thursday, May 7th, at the Hotel Cecil, Strand, W.C. The autumn meeting will be held in Birmingham on Wednesday, Thursday, and Friday, September 9th, 10th and 11th.

FARADAY MEDAL.—The Council of the Institution of Electrical Engineers has made the fourth award of the Faraday Medal to Sir J. J. Thomson, O.M., F.R.S., an honorary member of the Institution, and Master of Trinity College, Cambridge. The Faraday Medal is awarded by the Council of the Institution not more frequently than once a year, either for notable scientific or industrial achievement in electrical engineering or for conspicuous service rendered to the advancement of electrical science without restriction as regards nationality, country of residence, or membership of the Institution. Sir Joseph Thomson's publication in 1897 of his discovery of the existence of electrons and their emission from hot bodies was one of the fundamental stages in making possible the realisation of wireless telegraphy.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
Native	17/6 to 24/–
(1) Spanish	23/–
(1) N. African	23/–
N.E. COAST—	
Native	—
Foreign (c.i.f.)	22/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	4 15 0	—
No. 1 Foundry	4 12 6	—
No. 3 Foundry	4 10 0	—
N.E. COAST—		
Hematite Mixed Nos.	4 7 0	4 7 0
No. 1	4 7 6	4 7 6
Cleveland—		
No. 1	4 4 0	4 4 0
Silicious Iron	4 4 0	4 4 0
No. 3 G.M.B.	3 19 0	3 19 0
No. 4 Foundry	3 18 0	3 18 0
No. 4 Forge	17 0	3 17 0
Mottled	—	—
White	—	—
MIDLANDS—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 16 0 to 3 17 0	
,, Forge	3 11 0 to 3 12 0	—
(3) Derbyshire—		
No. 3 Foundry	4 2 0 to 4 2 6	—
Forge	3 17 0	—
(3) Lincolnshire—		
No. 3 Foundry	4 2 6	—
No. 4 Forge	4 0 0	—
Basic	4 5 0	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	5 2 6 (a) / 5 7 6 (b)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	12 0 0	—
Best ,,	—	—
N.E. COAST—		
Common Bars	12 0 0	—
LANCS.—		
Crown Bars	13 0 0	—
Second Quality Bars	12 0 0	—
Hoops	15 0 0	14 15 0
S. YORKS.—		
Crown Bars	13 0 0	—
Best ,,	13 10 0	—
Hoops	14 10 0	—
MIDLANDS—		
Crown Bars	12 15 0	—
Marked Bars (Staffs.)	15 0 0	—
Nut and Bolt Bars	11 15 0	—
Gas Tube Strip	13 0 0 to 13 5 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates	13 0 0	—
Ship Plates, ¾in. and up	9 15 0	—
Sections	9 10 0	—
Steel Sheets, 3/16in. to ¾in.	12 0 0	—
Sheets (Gal. Cor. 24 B.G.)	—	18 10 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	9 15 0	—
Angles	9 10 0	—
Boiler Plates	13 0 0	—
Joists	9 10 0	—
Heavy Rails	9 0 0	—
Fish-plates	13 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	9 10 0	—
Soft Billets	8 10 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	9 0 0†	—
Light ,,	9 5 0 to 9 10 0	
Billets	8 0 0 to 11 0 0†	
MANCHESTER—		
Bars (Round)	10 0 0 to 10 10 0	
,, (others)	9 15 0 to 10 0 0	
Hoops (Best)	15 5 0	15 0 0
,, (Soft Steel)	13 15 0	13 10 0
Plates	9 15 0 to 10 0 0	
,, (Lancs. Boiler)	13 0 0	—
SHEFFIELD—		
Siemens Acid Billets	11 10 0	—
Bessemer Billets	13 0 0	—
Hard Basic	9 10 0	—
Intermediate Basic	9 0 0	—
Soft Basic	8 0 0 to 8 5 0	
Hoops	12 0 0	—
Soft Wire Rods	11 0 0 to 11 10 0	
MIDLANDS—		
Small Rolled Bars	9 0 0 to 9 15 0	
Billets and Sheet-bars	7 5 0 to 7 10 0	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	17 5 0	—
Angles	9 5 0	—
Joists	9 5 0	—
Tees	10 5 0	—
Bridge and Tank Plates	9 15 0	—
Boiler Plates	13 10 0	—

NON-FERROUS METALS.

SWANSEA—	
Tin-plates, I.C., 20 by 14	23/6 to 23/7½
Block Tin (cash)	261 15 0
,, (three months)	265 0 0
Copper (cash)	65 7 6
,, (three months)	66 7 6
Spanish Lead (cash)	39 15 0
,, (three months)	38 0 0
Spelter (cash)	37 5 0
,, (three months)	36 12 6
MANCHESTER—	
Copper, Best Selected Ingots	71 10 0
,, Electrolytic	72 0 0
,, Strong Sheets	96 0 0
,, Tubes (Basis Price)	0 1 1½
Brass Tubes (Basis price)	0 1 0½
,, Condenser	0 1 2½
Lead, English	43 0 0
,, Foreign	41 0 0

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/8½ per lb.	
Ferro Tungsten	1/4½ per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£24 0 0	8/–
,, 6 p.c. to 8 p.c. ,,	£23 10 0	7/9
,, 8 p.c. to 10 p.c. ,,	£23 0 0	7/6
,, Specially Refined		
,, Max. 2 p.c. carbon	£43 0 0	16/–
,, ,, 1 p.c. ,,	£52 0 0	17/6
,, ,, 0.75 p.c. carbon	£60 0 0	20/–
,, ,, carbon free	1/5 per lb.	
Metallic Chromium	4/2 per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
,, Silicon, 45 p.c. to 50 p.c.	£11 15 0 scale 5/– per unit	
,, ,, 75 p.c.	£17 17 6 scale 6/– per unit	
,, Vanadium	17/6 per lb.	
,, Molybdenum	7/9 per lb.	
,, Titanium (carbon free)	1/2 per lb.	
Nickel (per ton)	£175	
Cobalt	10/– per lb.	
Aluminium (per ton)	£130	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	16/9
,, ,, Ell	18/3
,, ,, Splint	19/– to 23/–
,, ,, Trebles	18/1
,, ,, Doubles	17/6
,, ,, Singles	13/9
AYRSHIRE—	
(f.o.b. Ports)—Steam	16/9
,, ,, Splints	19/–
,, ,, Trebles	18/3
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	14/6 to 17/–
Screened Navigation	24/–
Trebles	18/3
Doubles	17/–
Singles	14/–
LOTHIANS—	
(f.o.b. Leith)—Best Steam	16/9
Secondary Steam	15/9
Trebles	19/–
Doubles	17/9
Singles	14/3

ENGLAND.

(8) N.W. COAST—	
Steams	28/6
Household	45/– to 58/4
Coke	30/–
NORTHUMBERLAND—	
Best Steams	18/4½ to 18/6
Second Steams	17/6
Steam Smalls	10/3 to 10/6
Unscreened	15/6 to 16/6
Household	23/6 to 25/–
DURHAM—	
Best Gas	21/– to 21/6
Second	18/– to 18/6
Household	23/6 to 25/–
Foundry Coke	23/– to 23/6

SHEFFIELD—	Inland.	
Best Hand-picked Branch	30/– to 33/–	
Barnsley Best Silkstone	26/– to 28/–	
Derbyshire Best Brights	26/– to 31/–	—
,, ,, House	24/– to 26/–	—
,, ,, Large Nuts	22/6 to 25/–	—
,, ,, Small	14/– to 16/–	—
Yorkshire Hards	19/6 to 23/–	—
Derbyshire ,,	19/6 to 22/–	—
Rough Slacks	9/6 to 12/–	—
Nutty ,,	8/6 to 10/6	—
Smalls	4/– to 6/6	—
Blast-furnace Coke (Inland)*	—	—
,, ,, (Export)	f.o.b.	21/6 to 22/6

(9) SOUTH WALES.

CARDIFF—	
Steam Coals :	
Best Smokeless Large	—
Second ,, ,,	26/– to 27/–
Best Dry Large	26/6 to 27/–
Ordinary Dry Large	24/– to 25/–
Best Black Vein Large	24/6 to 25/–
Western Valley ,,	23/6 to 24/6
Best Eastern Valley Large	23/6 to 24/6
Ordinary ,, ,,	22/6 to 23/–
Best Steam Smalls	16/– to 16/6
Ordinary ,,	13/– to 15/–
Washed Nuts	22/– to 32/–
No. 3 Rhondda Large	27/– to 27/6
,, ,, Smalls	19/– to 20/–
No. 2 ,, Large	22/6 to 23/6
,, ,, Through	18/– to 20/–
,, ,, Smalls	11/– to 13/–
Foundry Coke (export)	40/– to 47/6
Furnace Coke (export)	25/– to 30/–
Patent Fuel	25/– to 27/–
Pitwood (ex ship)	25/– to 26/–
SWANSEA—	
Anthracite Coals :	
Best Big Vein Large	45/– to 47/6
Seconds	36/6 to 37/6
Red Vein	32/6 to 35/–
Machine-made Cobbles	50/– to 55/–
Nuts	55/– to 57/6
Beans	44/– to 45/–
Peas	20/– to 23/6
Breaker Duff	9/– to 9/6
Rubbly Culm	10/– to 10/6
Steam Coals :	
Large	24/6 to 25/6
Seconds	22/6 to 24/6
Smalls	14/– to 16/–
Cargo Through	17/– to 19/–

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/– extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b.

• For blast-furnaces only, 16/9, with fluctuations according to analysis; open market, round about 22/6 to 25/– at ovens. † Latest quotations available. (a) Delivered Sheffield or Glasgow. (b) Delivered Birmingham.

French Engineering Notes.

(From our Correspondent in Paris.)

Agricultural Engineering.

SINCE the heavy demand for agricultural machinery in this essentially agricultural country turned the attention of French makers to this field of activity at a time when they were looking for something to occupy the works and factories that had been created during the war, the construction of such machines has grown so enormously that manufacturers now declare they are able to supply everything the farmer needs, with the sole exception of self-binding reapers. The show that was held last week on the site of the new Palais de l'Exposition at the Porte de Versailles certainly appeared to justify these claims. The industry itself is so well organised that the most complete propaganda work is carried out to protect home makers and to convince French agriculturists of the superiority of French products. During the year this propaganda has failed to give the desired results, for users of French implements and machines have been complaining of their poor quality and have succeeded in impressing upon the Government the necessity of facilitating the importation of foreign machines which have always given them satisfaction. There has consequently been a good deal of recrimination between agriculturists and implement makers, these latter declaring that the agitation aims solely at letting in competition and bringing down prices, and affirming that if foreign machines are admitted under such favourable conditions as are proposed the home industry will be practically ruined. The Government hopes to compromise by lowering the import duties on agricultural machinery and promising to do what it can to provide home makers with cheaper raw material. Until recently British firms have been doing very little in this country, on account of the exchange rate putting up prices to what the French farmer regards as a prohibitive level. The exchange rate is, in fact, held as a grievance against the British, who are accused of bringing up their currency to the gold standard from selfish motives, without any consideration for the unfortunate dilemma in which the franc is placed. Nevertheless, it appears fairly certain that many farmers who have been using cheap machinery find that it is to their interest to return to foreign productions, despite the higher prices, and it appeared at the show to be quite possible that if the duties are lowered, as is promised, and if the franc should improve a little, there will be a recovery in the sales of English goods in this country.

Oil Engines.

The popularity of the heavy oil engines was one of the most striking features at the Paris show. Even the promises that are made of the future distribution of cheap electrical energy have failed to convince farmers that they will find a more economical form of power than internal-combustion engines using crude oils, providing that the heavier oil consumption does not inflate prices of the fuel, and the amount of business done in these prime movers at the show must have been large. Nearly all the English makers were represented, and some at least sold a fair number of engines. The French are giving special attention to modified forms of the Diesel type, while the Société " L'Aster " is constructing a high-speed engine under Austrian patents which is claimed to give remarkable results from the point of view of fuel consumption. Many of these crude oil engines were mounted as portables. There is a general idea that the crude oil engine will supersede the steam portable engine in the same way that the tractor is taking the place of the steam traction engine.

Foreign Trade.

With the trade returns for 1924 showing a notable increase of exports over imports France has succeeded in attaining the " balance of trade " which she regards as a sign of commercial prosperity and as necessary for the recovery of her financial situation. It is supposed to mean that the country is supplying more and more of its own needs and that the selling of goods abroad in excess of the weight and value of what is imported is so much gain. In so far as the figures show that French manufacturers are supplying more for home requirements, and do not imply a falling off in the country's purchasing power, the gain is real. The immediate cause of this heavier production is, of course, the prohibitive cost of goods from countries with a normal currency, which means that French makers have had to lay themselves out to produce similar goods at prices that home consumers can pay, and as the franc has heavily depreciated they have readily found markets abroad for their manufactures. The returns in values are somewhat misleading, since with the fluctuation of the franc there is no real standard, but the increase in values nevertheless represents an actual gain, and is confirmed to a large extent by the weights. In 1924 the total value of imports was estimated at 40,132 million francs, showing an increase of 7443 million francs on the previous year. Of this total raw material accounted for 26,138 millions, and manufactured goods for only 5088 millions, representing an increase of 711 million francs. The exports in 1924 were valued at 41,454 million francs, an increase of 11,021 millions. A remarkable feature of these returns is that manufactured goods were responsible for 24,861 millions, or 8622 millions more than in 1923. This does not include 2064 million francs worth of goods sent by post. These large exports of manufactured goods, the values of which were increased by the depreciation of the franc, explain the apparent discrepancy in tonnage. In 1924 the imports amounted to 56,491,788 tons, an increase on the previous year of 1,627,105 tons, but this augmentation was due almost entirely to raw material, which accounted for 49,342,178 tons out of the total. Manufactured goods only slightly increased to 1,476,722 tons. The exports, amounting to 29,385,799 tons, were 4,484,107 tons in excess of those for 1923. The increase was due principally to raw material, which accounted for 24,106,412 tons. Manufactured goods totalled 3,608,152 tons, an increase of 538,861 tons.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

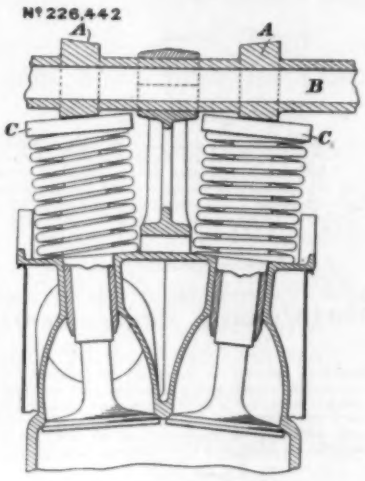
Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

226,442. June 12th, 1924.—VALVE GEAR, M. S. Napier, Villa des Cistes, Chemin du Roi Albert, Cannes, France; and G. S. Wilkinson, 211, Acton-vale, London, W. 3.

The object of this invention is to permit the use of inclined valves without the necessity for complicated gear. The cams A

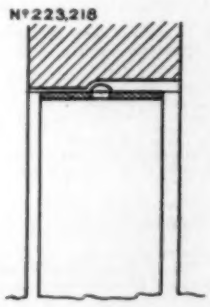


on the cam shaft B consequently have their faces inclined, as shown, to make them normal to the axis of the valves. The tappet rods C telescope into the valve stems and are acted on directly by the cams.—*December 24th*, 1924.

TURBINE MACHINERY.

223,218. September 30th, 1924.—BLADE SHROUDING, Erste Brünner Maschinen-Fabriks-Gesellschaft, 5, Glockengasse, Brünn, Czecho-Slovakia.

With riveted-on shrouding it is necessary to leave the rivet heads protruding, as the shrouding is not thick enough to accom-

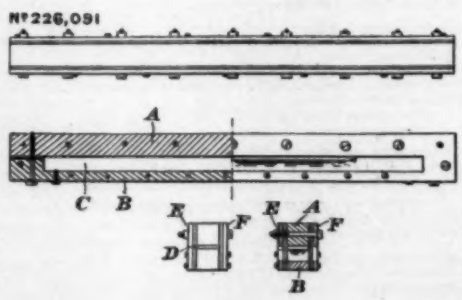


modate countersunk heads. The projecting heads ordinarily require extra circumferential clearance, and this results in loss of efficiency. The difficulty is overcome by the inventors in the manner shown, which needs no explanation.—*December 24th*, 1924.

MEASURING AND TESTING INSTRUMENTS.

226,091. April 24th, 1924.—SPIRIT LEVELS, E. B. H. Wade, Physical Department, Public Works Ministry, Cairo, Egypt.

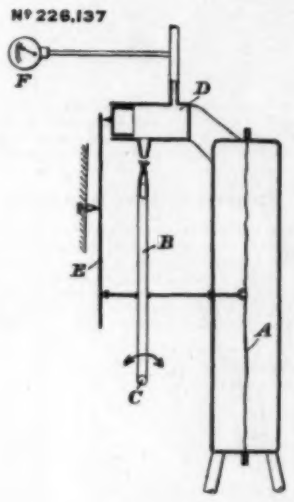
In this specification the inventor says that, as hitherto constructed, the ordinary spirit level is a very reliable instrument for giving inclinations to about one second of arc, but for smaller



inclinations difficulties arise which are largely of thermal origin and are traceable to the fact that the spirit level is made of glass, while the rest of the apparatus to which it is attached and the inclination of which it is required to record is usually made of metal, whereby unequal thermal expansion results and is productive of a change in zero and sensitiveness, while even in the absence of metal the fact that glass is so bad a conductor of heat prevents any chance local heating from generalising itself over the whole apparatus with a similar result. Moreover, it is well known that glass, after undergoing a cycle of thermal or mechanical changes, suffers from elastic after-effects and does not return to its initial form when the cycle is completed. He consequently forms his spirit level with a body part of brass or other suitable material comprising an upper member A (termed the concave) and a lower member B (termed the trough) having flanged portions forming the end walls of the bubble chamber C, while the side walls are formed from plain sheets D of glass, celluloid or like material cemented or otherwise secured in position as by the frames E F. The whole thus forms a substantially rectangular bubble chamber in which the essential parts or parts affecting the equilibrium of the bubble are of metal, while the plain glass or other transparent side walls play no part in the bubble equilibrium, but merely serve as windows through which the bubble may be viewed so that its position may be properly determined.—*December 18th*, 1924.

226,137. September 20th, 1923.—MANOMETERS, G. Wünsch, Stindestrasse 2, Berlin-Steglitz, Germany; and Askania-Werke A.G., vormals Centralwerkstatt-Dessau und Carl Bamberg-Friedenau, Kaiser Allee 87/88, Berlin-Friedenau, Germany.

This instrument is intended to increase small pressure differences so that they may be more readily readable. The two pressures act on the two sides of the diaphragm A which is connected with the pipe B. B is pivoted at C and is supplied with

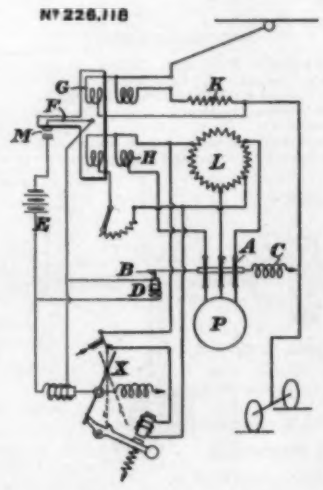


compressed air. The jet issuing from its end is directed into a cylinder D, which is provided with a piston. This piston is connected with a lever E to which the diaphragm is also attached. If the two pressures to be determined vary, the diaphragm moves the jet of air more or less into alignment with the opening in the cylinder D and the pressure therein is consequently changed. The piston reacts on the diaphragm through the lever E until equilibrium is attained. The pressure in the cylinder D is read on a gauge F.—*December 18th*, 1924.

TRAMWAYS AND RAILWAYS.

226,118. July 11th, 1924.—IMPROVEMENTS IN ARRANGEMENTS FOR THE AUTOMATIC STARTING AND RE-SYNCHRONISING OF SYNCHRONOUS PHASE-CONVERTERS, Kálman von Kandó, of Rozsa-Utca, 46, Budapest, Hungary.

This invention relates to the new system of railway electrification described by Mr. Verebely in our issue of December 5th, 1924. The invention embodies an arrangement for bringing the phase-converter into synchronism if it should fall out of step, or for re-starting it if it should come to rest. In the secondary circuit of the phase-converter there is a circuit breaker A, which is held in the closed position by a projection B against the pull of a spring C. The projection B can be released by an electromagnet D, which is connected in circuit with a source of current



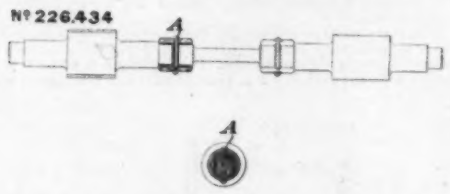
E by means of the contact lever F. This lever is subjected to the action of two wattmeters. The wattmeter G is in the circuit of the primary winding K of the phase converter, whilst the other wattmeter is in the secondary circuit L of the phase-converter. The two wattmeters are so arranged that they operate on the control lever F in opposite directions. Under normal conditions, owing to the losses in the phase-converter, the load on the primary is greater than the load on the secondary, so that the effect of the wattmeter G exceeds that of the wattmeter H, and consequently the contacts M open. But if the current be interrupted or the phase-converter falls out of step, the current taken by the converter also falls to zero and the wattmeter G becomes inoperative. The wattmeter H then moves the

contact lever F, which closes the contacts M. The release magnet P is energised, and the circuit breaker A is opened and the motor P is disconnected. If the disconnection of the motor P takes place with sufficient rapidity after the interruption of the primary circuit or after the phase converter has fallen out of step, the phase-converter will still be rotating sufficiently fast to enable it to increase its speed when the current is again supplied to it, and it will pull into step again, when the motor can be connected up. In order, however, to bring the phase-converter into synchronism automatically, if the interruption of the primary current lasts so long that the speed of the phase-converter is insufficient to enable it to attain synchronism, a starting switch X is provided. A long description explaining the action of this switch is given.—*December 18th*, 1924.

MACHINE TOOLS AND SHOP APPLIANCES.

226,434. May 22nd, 1924.—ROLLING MILL COUPLINGS, J. P. Ashley and L. D. Whitehead, Courtybella Works, Newport, Mon.

The object of this invention is to prevent the endways move-

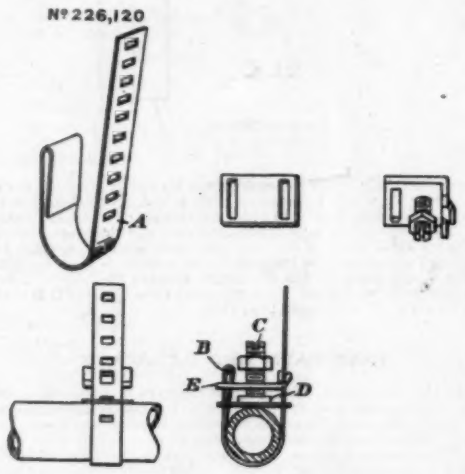


ment of the wobbler couplings used for rolling mills and consists in the provision of a through bolt A arranged between the adjacent ends of the shafts. The arrangement is said to be safer than the usual bound-on distance pieces.—*December 24th*, 1924.

LIGHTING AND HEATING.

226,120. July 12th, 1924.—IMPROVEMENTS IN BONDING CLIPS FOR ELECTRIC WIRING SYSTEMS, Callender's Cable and Construction Company, Limited, of Anchor Works, Leigh; and Stanley James Bryce, of the same address.

A bonding strip made in accordance with this invention consists of a metal strip which is used in combination with a bridge piece as shown. One end of the metal strip A is lapped back upon

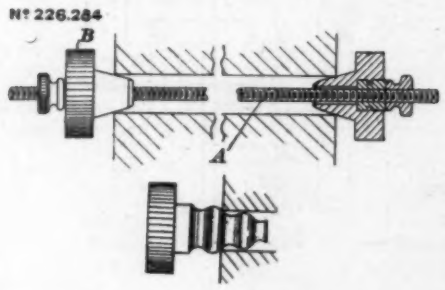


itself and is threaded through a hole in the bridge piece, whilst the other end has a number of slots, one of which is adapted to connect with a projection on the opposite side of the bridge piece so as to form a bonding which can be adapted to pipes of different sizes. The earthing wire is inserted at B. By rotating the screw C the plate D is brought into firm contact with the pipe, whilst the earthing wire is locked by the bridge piece E.—*December 18th*, 1924.

MISCELLANEOUS.

226,284. September 20th, 1923.—IMPROVEMENTS IN OR RELATING TO ELECTRICAL LEADING-IN CONDUCTORS, Hugh Glover Bell, of 4, Chelmford-road, Manchester; and Metropolitan-Vickers Electrical Company, of 4, Central-buildings, Westminster.

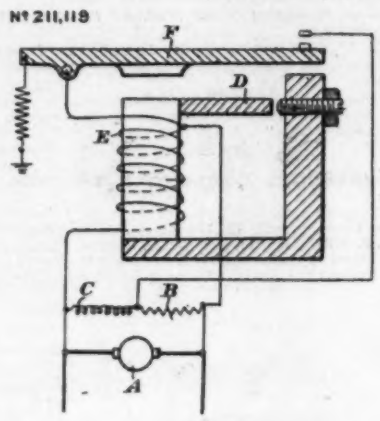
This specification describes a simple and very effective form of lead-in insulator for wireless and other purposes. It will be seen



from the illustration that the conducting rod, which is screwed, passes through a hole in a wall or other partition, and that the ends there are conical insulating bushings B. Owing to the size of the hole there is a good clearance between the conductor and the wall. In order to prevent rain water from running down the taper portion of the insulators the taper portion may be provided with ridges and troughs as shown in the lower illustration.—*December 22nd*, 1924.

211,119. January 30th, 1924.—IMPROVEMENTS IN AND RELATING TO ELECTRO-MAGNETIC RELAYS AND THE LIKE, *The British Thomson-Houston Company, of Crown House, Aldwych, W.C. 2.*

The object of this invention is to compensate variations in the temperature of the windings of electro-magnetic relays, such as voltage regulators, &c. The voltage regulator shown regulates the voltage of a generator A by periodically cutting resistance B out and inserting it in the field winding C in accordance with the well-known principle of vibratory voltage regulators. Variations in the operation of the relay resulting from a



rise in temperature of the windings are compensated by the magnetic member D, which, on account of its proximity to the winding E, becomes heated and its permeability consequently decreases. An increased percentage of the flux therefore passes through the armature F and the effect produced by the heating of the winding E is compensated.—*December 18th*, 1924.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's Gate, Westminster, London, S.W. 1. Informal discussion on "Alternatives to the 'Clash' Type of Change-speed Gear for Motor Vehicles." 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Lecturette, "Notes on High Voltage Electrical Transmission," by Mr. E. Ambrose. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, London, W. 1. Discourse, "The Mountain Structure and Geographical Relations of South-Eastern Asia," by Professor John W. Gregory. 9 p.m.

SATURDAY, JANUARY 31ST.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—The Guildhall, York. Quarterly meeting of the Yorkshire District. 2.30 p.m.

WEST YORKSHIRE METALLURGICAL SOCIETY.—Technical College, Bradford. Joint meeting with the Institute of British Foundrymen. Paper on "Scrap Metals," by Mr. G. Ledgard. 6.30 p.m.

WOMEN'S ENGINEERING SOCIETY.—Visit of the London Branch to the Hackney Power Station and Sub-stations. 2.30 p.m.

MONDAY, FEBRUARY 2ND.

BRADFORD ENGINEERING SOCIETY.—Technical College, Bradford. Lecture, "The Ultimate Position of the Single-phase Motor in Electric Power Distribution," by Mr. W. A. Benger. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Watergate House, Adelphi, London, W.C. 2. Extraordinary general meeting. 4 p.m.

INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Neville Hall, Newcastle-upon-Tyne. Paper, "Subsidence Due to Coal Workings," by Mr. W. C. Knill. 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Informal meeting for a further discussion on the I.E.E. Wiring Regulations. 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS: NORTH-WESTERN SECTION.—Manchester Geographical Society's Rooms, 16, St. Mary's Parsonage, Manchester. Lecture, "The Design and Construction of a Piano Player," by Mr. G. B. Walker. 7.15 p.m.

SOCIETY OF ENGINEERS.—Geological Society's Rooms, Burlington House, Piccadilly, London, W. 1. Presidential address, by Mr. A. Stewart Buckle. 5.30 p.m.

TUESDAY FEBRUARY 3RD.

INSTITUTION OF CIVIL ENGINEERS.—Great George-street, Westminster, London, S.W. 1. Further discussion on "The Southampton Floating Dock," by Dr. E. H. Salmon, and "Southampton Floating Dock: Subsidiary Works," by Mr. F. E. Wentworth-Shields. 6 p.m.

INSTITUTE OF MARINE ENGINEERS.—85/88, The Minories, Tower Hill, London, E. 1. "The Treatment of Boiler Feed Water," by Messrs. W. B. Lewis and G. S. Irving. 6.30 p.m.

INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Chamber of Commerce, New-street, Birmingham. Discussion on "Metal Melting." 7 p.m.

INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—Electrical Engineering Theatre, Armstrong College, Newcastle-on-Tyne. Open discussion. 7.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS: COVENTRY CENTRE.—Broadgate Café, Coventry. Paper, "Some Notes on British Methods of Continuous Production," by Mr. F. G. Woollard. 7 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND STUDENTS' SECTION.—The University, Leeds. Paper, "Boiler Corrosion and Feed Water Treatment," by Mr. P. Austin. 7 p.m.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "Decomposition of Paraffin Wax at 450 deg. Cent. in Presence and in Absence of Hydrogen under High Pressure," by Dr. H. I. Waterman and Mr. J. N. J. Perquin. 5.30 p.m.

WENESDAY, FEBRUARY 4TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—The College, Loughborough. Loughborough Graduates' meeting. Paper, "High-speed Engines," by Mr. H. R. Ricardo. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Midland Hotel, Derby. Derby Graduates' annual dinner. 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS.—Students' visit to Neasden Carriage and Wagon Works, Metropolitan Railway.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Wireless section meeting. "The Optimum Damping in the Auditive Reception of Wireless Telegraph Signals," by Messrs. L. B. Turner and F. P. Best. 6 p.m.

THURSDAY, FEBRUARY 5TH.

INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Queen's Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. Sixteenth Kelvin Lecture, "Electrical Forces and Quanta," by Dr. J. H. Jeans. 6 p.m.

INSTITUTION OF MECHANICAL ENGINEERS: NORTH-WESTERN BRANCH.—The Engineers' Club, Manchester. Reports to the Cutting Tools Research Committee, "Flow and Rupture of Metals during Cutting," by Dr. W. Rosenhain and Mr. A. C. Sturrey; and "Report on an Experimental Study of the Forces Exerted on the Surface of a Cutting Tool," by Dr. T. E. Stanton and Mr. J. H. Hyde. 7 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Lecture, "The Properties and Structure of Quartz—II.," by Sir William Bragg. 5.15 p.m.

FRIDAY, FEBRUARY 6TH.

INSTITUTION OF MECHANICAL ENGINEERS.—Storey's Gate, Westminster, London, S.W. 1. "Anti-friction Bearing Applications for Heavy Duty," by Mr. J. B. Dahlerus. 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Lecturette, "The Measurement of Hardness and Allied Properties of Metals," by Mr. E. G. Herbert. 7.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, London, W. 1. Discourse, "The Earliest Recorded Kings of the English," by Professor R. W. Chambers. 9 p.m.

SATURDAY, FEBRUARY 7TH.

INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Grand Hotel, Aytoun-street, Manchester. Lecture, "A Psychological Examination of Foundry Life," by Mr. V. C. Faulkner. 4 p.m. To be followed by annual dinner at 6.30 p.m.

MONDAY, FEBRUARY 9TH.

INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. Paper, "Methods of Keeping Foundry Records," by Mr. J. A. Gardner. 7.30 p.m.

TUESDAY, FEBRUARY 10TH.

INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH, BURNLEY SECTION.—Municipal College, Ormerod-road, Burnley. Paper, "Machine Tool Work," by Mr. H. Jowett. 7.15 p.m.

INSTITUTE OF MARINE ENGINEERS.—85-88, The Minories, Tower-hill, London, E. 1. President's address. 6.30 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "Some Notes on British Methods of Continuous Production," by Mr. F. G. Woollard. 7 p.m.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Broadgate Café, Coventry. Coventry Graduates' meeting. Paper, "Aluminium, its Alloys and their Use in the Automobile Industry," by Mr. G. H. Day. 7.15 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND CENTRE.—Hotel Metropole, King-street, Leeds. Informal discussion on "Domestic Electrical Apparatus." 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS.—Midland Hotel, Manchester. Anniversary dinner. 6.15 for 6.45 p.m.

WEDNESDAY, FEBRUARY 11TH.

INSTITUTION OF AUTOMOBILE ENGINEERS: WOLVERHAMPTON CENTRE.—The Engineers' Club, Wolverhampton. Paper, "Some Notes on British Methods of Continuous Production," by Mr. F. G. Woollard. 7.30 p.m.

THURSDAY, FEBRUARY 12TH.

INSTITUTE OF METALS: LONDON LOCAL SECTION.—Institute of Marine Engineers, 85-88, The Minories, London, E. 1. Paper, "Some Notes on Refractory Materials," by Mr. V. C. Faulkner. 7.30 p.m.

FRIDAY, FEBRUARY 13TH.

DIESEL ENGINE USERS' ASSOCIATION.— The Engineers' Club, Coventry-street, London, W. 1. Paper, "Submarine Engines and High-speed Heavy-Oil Engine Electric Generating Sets," by Mr. P. A. Holliday. 3.30 p.m.

INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—198, West-street, Sheffield. Joint meeting with the Sheffield Metallurgical Association. Paper, "Fuel and its Efficient Utilisation," by Dr. C. H. Lander. 7.30 p.m.

INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Metallurgical Department, University College, Singleton Park, Swansea. Paper, "Season Cracking and its Prevention," by Dr. H. Moore. 7.15 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. Honorary members' lecture, "Milestones in the Development of the Prime Mover Locomotive," by Mr. Loughnan Pendred. 7.30 p.m.

SATURDAY, FEBRUARY 14TH.

INSTITUTION OF AUTOMOBILE ENGINEERS.—Florence Restaurant, Rupert-street, London, W. 1. London Graduates' annual dinner. 7.30 p.m.

MONDAY, FEBRUARY 16TH.

JUNIOR INSTITUTION OF ENGINEERS: NORTH-WESTERN SECTION.—Geographical Society's Rooms, 16, St. Mary's Parsonage, Manchester. Lecture, "The Design and Construction of the No. 5 Gas Holder for Burnley Corporation," by Mr. A. D. Young. 7.15 p.m.